SAE JOURNAL

September 1949

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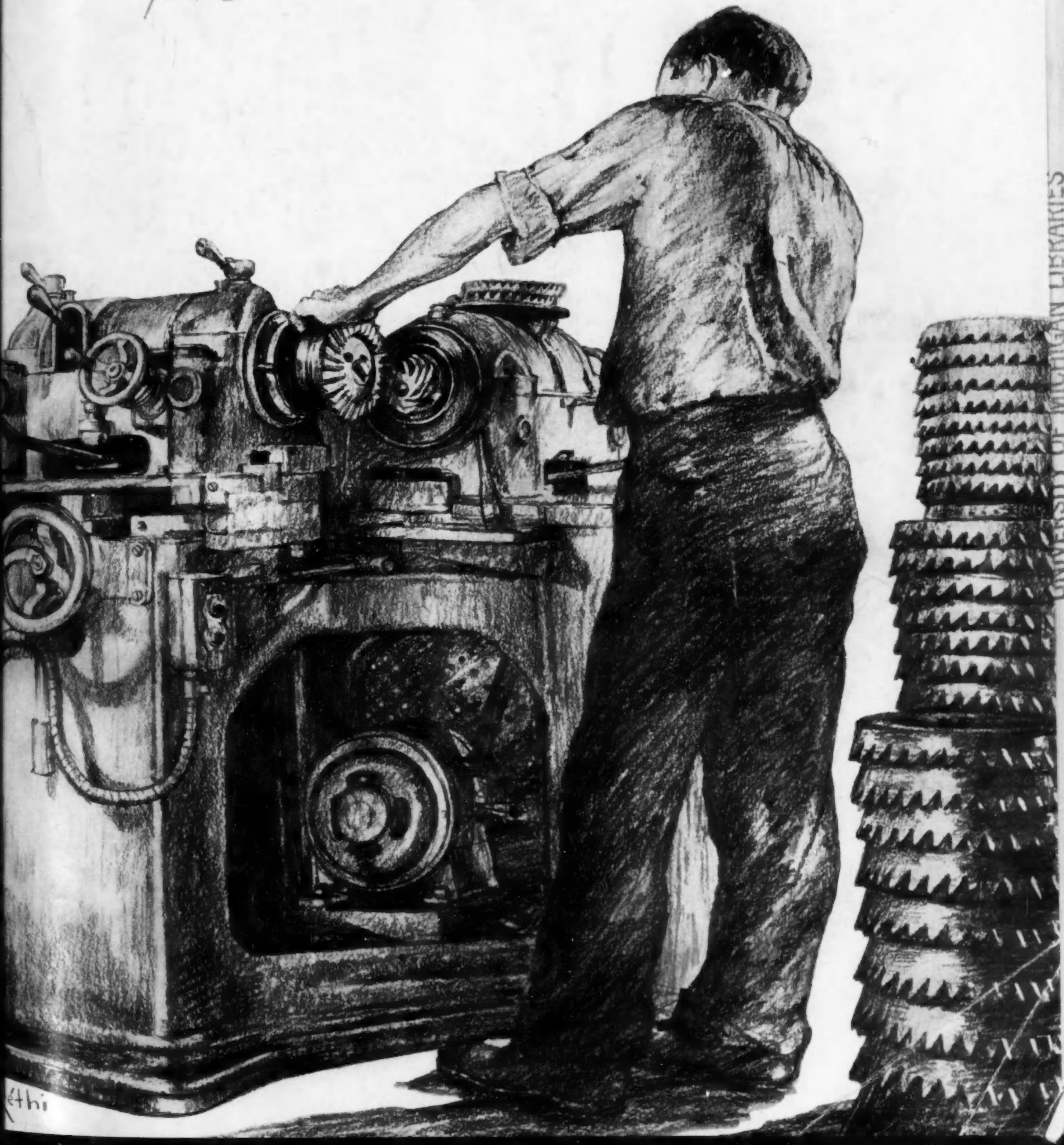
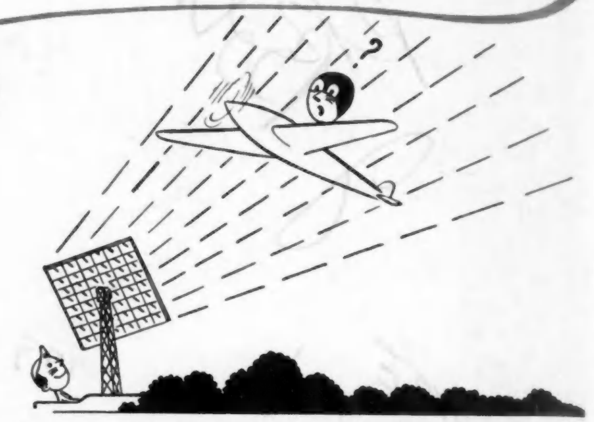


THE PERFECT CIRCLE

Rumor Page

IT'S RUMORED THAT: ***Thousands and thousands of motorists will be "locked out" of their cars in '49!***

THAT'S A FACT! Records show that over 640,000 motorists locked their keys in their cars in 1948—and human behavior isn't likely to change overnight!

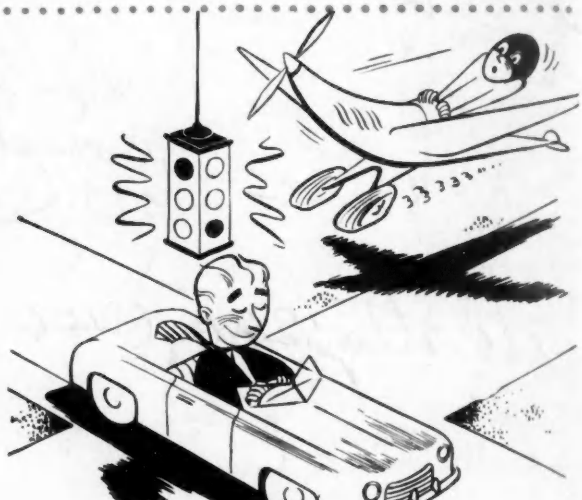


IT'S RUMORED THAT: ***Radar beams can set fire to aviation fuel!***

RIGHT! It's been done in tests by a leading aircraft company—but only at limited distances and in certain circumstances. May develop into a great weapon, though.

IT'S RUMORED THAT: ***There's a PC piston ring that "digests" abrasives!***

KEE-RECT! The PC Solid Chrome Plated Ring is so hard it breaks up abrasive material into smaller, less harmful particles with duller edges! The wear-rate of these rings is as much as 80% less than unplated rings!



IT'S RUMORED THAT: ***Stop lights now keep planes and cars from tangling!***

RIGHT AGAIN! Merrill Field in Anchorage, Alaska, has erected a stop light at an intersection where a highway crosses an airstrip!

*—Contributed by Mrs P. A. Seigler, 1007 N. Davis St., Albany, Ga.**

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TABLE OF CONTENTS

SAE NOMINEES FOR 1950

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Advantages of Aircooling

REAPPRAISAL of the suitability of aircooled engines for commercial ground vehicles shows that they offer some important advantages over cast-iron liquid-cooled engines.

Aircooled engines possess not only the traditionally cited advantages of lack of plumbing difficulties, elimination of antifreeze problems, and light weight. They also save on fan power, require less cooling air, avoid the power loss due to combustion chamber deposits, and warm up faster.

Aircooling and liquid cooling score about the same on cost, availability of manufacturing facilities, life, noise, fuel consumption, and antidetonation quality. Only in the matter of hotter exit cooling air is the aircooled engine at a disadvantage.

Of course, the final answer on the suitability of

BACHLE reappraises aircooled engines in the light of his company's experience in developing two series of aircooled engines to fulfill military need for a 100-1000-hp line of all-climate engines having maximum interchangeability of parts. In his complete paper, he explains that:

Continental achieved the range of power ratings by 4-, 6-, and 8-cyl combinations of a 4.62-in.-bore cylinder (Fig. 1) and 6-, 8-, and 12-cyl combinations of a 5.75-in.-bore cylinder (Fig. 2). This standardization of cylinders provides interchangeability within each series of the parts that wear most—like valves, pistons, and rings. Parts like crankshafts which cannot be interchangeable among engines having different numbers of cylinders are at least similar. Some units, like fans, fan drive clutches, magnetos, oil filters, and spark plugs, are identical for both series.

The all-climate requirement dictated aircooling to circumvent difficulties with liquid coolants at low ambient temperatures. Aircooling suits the individual-cylinder construction and is consistent with two other requirements: light weight and small bulk.

Performance of these aircooled engines is equal or superior to most liquid-cooled engines used in vehicles today. Figs. 3 and 4 show performance of the single cylinders.

Fan horsepower does not exceed 5% of gross horsepower up to rated speed. But cooling may absorb more than 5% of gross power in military installations where extra cooling capacity must be provided for air inlet and outlet ducting losses, margin for high ambient temperatures, engine oil coolers, and oil coolers for torque converters.

Both pressure cooling, where air flows from fan to cylinders, and suction cooling, where air flows from cylinders to fan, give excellent results.

Two types of fan drive are available: a centrifugally actuated friction clutch and an eddy-current electric drive. Both satisfy the military requirement for avoidance of belts and provision for unloading the fan in case of underwater operation. Additional advantage of the eddy-current drive is that it can control cylinder temperatures. A temperature-sensitive element on the cylinders controls current to the clutch, thus regulating fan speed to suit cylinder temperature.

The aircooled engines weigh only about one-third as much as liquid-cooled, heavy-duty vehicle engines of the same power (Fig. 5). The aircooled engines are lighter because of weight advantages inherent in aircooling and the application of modern experimental stress analysis methods. And the horizontally-opposed cylinder arrangement of the five engines in the 125-to-500-rated-hp range brings additional weight savings due to elimination of crankshaft counterweights and greater crankcase stiffness in the fore-and-aft plane.

These aircooled vehicle engines do weigh about 10% more than aircooled aircraft engines of comparable size. This extra weight was designed into the engines in order to reduce bearing loads, temperatures, and cost; to ensure extra long life; and to meet part-load requirements not imposed by aircraft service.

Pendulum-type dampers on all engines in the two lines reduce crankshaft stresses due to torsional vibration. Where the vehicle drive system alters vibration characteristics so that dampers are not needed, they can be omitted.

for Vehicle Engines

BASED ON PAPER* BY **C. F. Bachle**

Vice-President in Charge of Research
Continental Aviation and Eingeering Corp.

aircooling for commercial ground vehicle engines must come from commercial experience. But aircooling's advantages—and military experience—indicate it is worth trying.

Where Aircooling Excels

Here are seven advantages of aircooling, taken one by one:

1. *Freedom from Plumbing Troubles*—Since the aircooled engine requires no liquid coolant, it requires no plumbing. It eliminates the 4 to 40 hose clamps plus the water pump, jacket plugs, and gaskets that offer literally hundreds of places for leakage.

Service records of liquid-cooled engines show that cooling systems cause about 20% of service interruptions. Aircooled engines can eliminate nearly all of the 20%.

2. *Freedom from Antifreeze Troubles*—Just as aircooling avoids plumbing troubles, it avoids antifreeze troubles. This is important to commercial operators, who often resort to idling engines for hours or draining cooling systems in cold weather rather than contend with the expense and uncertainty of ordinary antifreezes.

Aircooling presents no clogging problems comparable to the clogging of liquid-cooled systems by corrosion resulting from antifreeze and salts contained in the water—or to clogging of the radiator on the air side. Aircooled cylinder fins seldom clog, probably because the shock of combustion shakes deposits loose.

3. *Light Weight*—Aircooled engines are basically lighter than liquid-cooled engines. All indications are that the installed engine weight of an aircooled engine will be about half that of a liquid-cooled engine of the same power, even if the problems of corrosion and leakage of aluminum water jackets

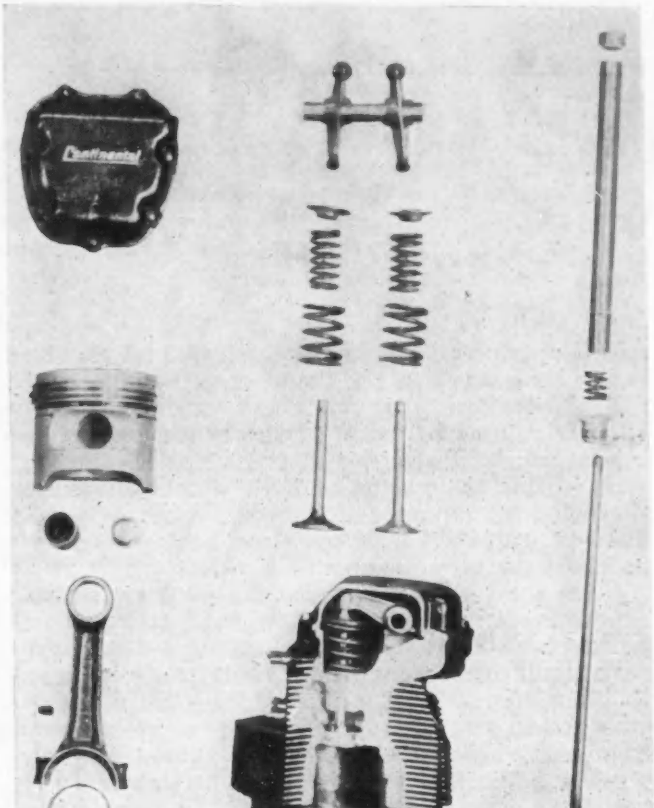


Fig. 1—Smaller (67-cu-in. displacement) cylinder and interchangeable parts

*Paper "Aircooled Engines for Vehicles" was presented at Detroit Section on Jan. 31, 1949, and, with additions, at SAE National Passenger Car, Body, and Production Meeting, Detroit, on March 10, 1949 and at SAE West Coast Meeting, Portland, Oregon, on August 15, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

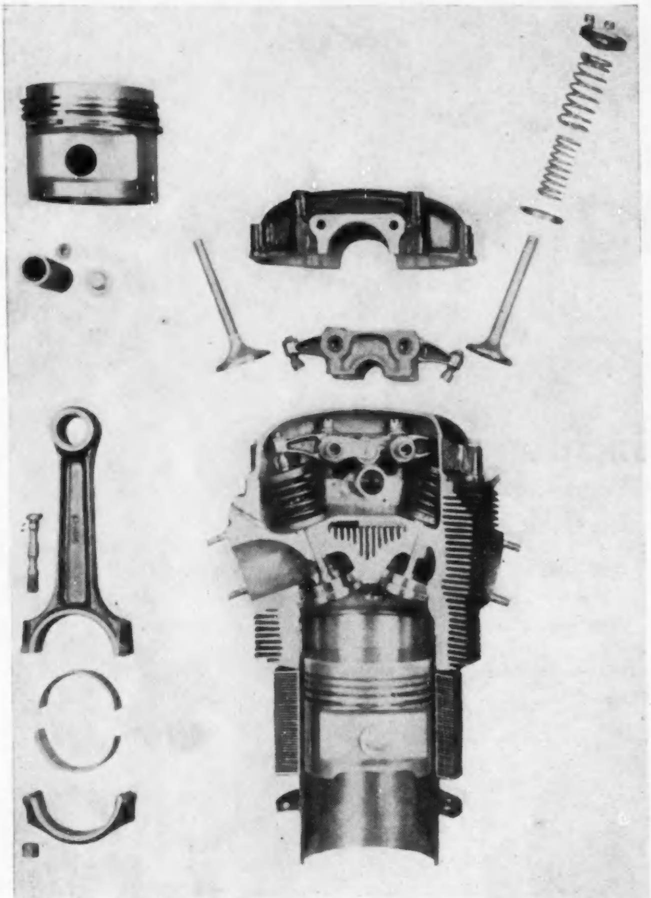


Fig. 2—Larger (149-cu-in. displacement) cylinder and interchangeable parts

are solved and aluminum is substituted for cast iron wherever possible in the liquid-cooled engine.

Studies show that aircooled engines have a smaller volume of metal in the cylinder from the crankcase out to the tip of the cylinder. Besides, most of this volume can be light-weight aluminum. Aircooled aluminum cylinders are made with only 0.100-in. wall thickness; cast-iron liquid-cooled cylinders must use walls about 0.250-in. thick.

4. Small Fan-Power Requirement—There is ample experimental evidence to show that aircooled engines can be designed so that they use less fan power than liquid-cooled engines. Where there is no assistance from forward motion of the vehicle, the engine can be aircooled for about 5% of gross power. At a vehicle speed of about 70 mph, ram air can supply all the cooling effort and no cooling power is needed.

5. Small Cooling-Air Requirement—Aircooled engines actually require only about half the cooling air that liquid-cooled engines do. Therefore, aircooled engines use less of the volume inside the vehicle for cooling-air entrance and exit ducts.

6. Conservation of Original Power—Aircooled engines do not suffer the power reduction that some liquid-cooled engines, particularly L-head engines, experience during the first 100 hours of operation. This power loss, which is sometimes as high as 14%, is due mostly to volumetric efficiency loss. Probably the reason that aircooled engines do not suffer the loss is that higher average (not maximum) combustion chamber wall temperatures inhibit the deposit buildup that cuts down volumetric efficiency.

7. Faster Warmup—Aircooled engines warm up faster because, with their smaller mass, there is less thermal lag. Also, the warmer intake port in the cylinder head improves warmup and cold-weather operation.

Faster warmup and higher temperatures in the lower region of piston travel and in the valve spring chamber probably explain why aircooled engines show less sludge in the oil system.

Where Systems Are About Equal

On these six counts, aircooling and liquid-cooling are about equal:

1. Cost—About half the weight of an aircooled engine consists of parts of the same type and workmanship as liquid-cooled engines use. Another 10% of aircooled engine weight consists of accessories, which are similar for both types of engines. Aluminum crankcase and cylinder heads make up the remaining 40% of the aircooled engines.

Aluminum has about the same strength and is used at about the same stress level as cast iron, but aluminum costs about 25% more per cubic inch than cast iron.

But that doesn't mean that the finished aluminum parts will cost 25% more than cast-iron parts of the same volume. Aluminum machines more economically. Besides, the aircooled engine parts can be smaller, which means less waste with scrapped parts. And still further economies may stem from the fact that size and design of aircooled engine parts allow fabrication by permanent-mold or die casting.

2. Manufacturing Facilities—Plants and machinery used for manufacturing liquid-cooled engines could serve for all aircooled-engine parts except cylinders and cylinder heads. These must be aluminum for heat-conductivity reasons. But they are small enough for die casting and automatic machining. And the individual-cylinder construction possible with aircooling would justify the most advanced type of cost-saving machinery and tooling.

3. Life—Service experience with aircooled engines, including 20 years of aircraft service and the 30,000,000 hp installed in tanks used in the last war, backs up the claim that aircooled engines last as long as present-day liquid-cooled vehicle engines.

4. Noise—It is true that no really quiet aircooled engine has appeared, but that is because until recently there was insufficient demand for quietness. Now reduction of the major noise producers in personal aircraft has created demand for quieter aircooled engines, and they will be developed. One answer may be replacement of audible accessory-drive spur gears with spiral gears.

In any case, the sound insulation between present liquid-cooled engines and passengers will probably be adequate for aircooled engines.

5. Fuel Consumption—Experience shows that fuel consumption of aircooled and liquid-cooled engines is about the same when both are developed to use fuel of a given octane rating. The aircooled engine

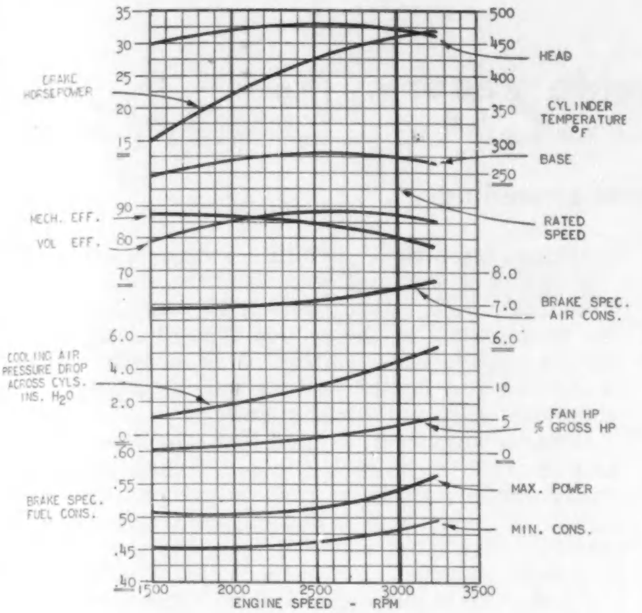


Fig. 3—Performance of 67-cu-in. cylinder at full throttle

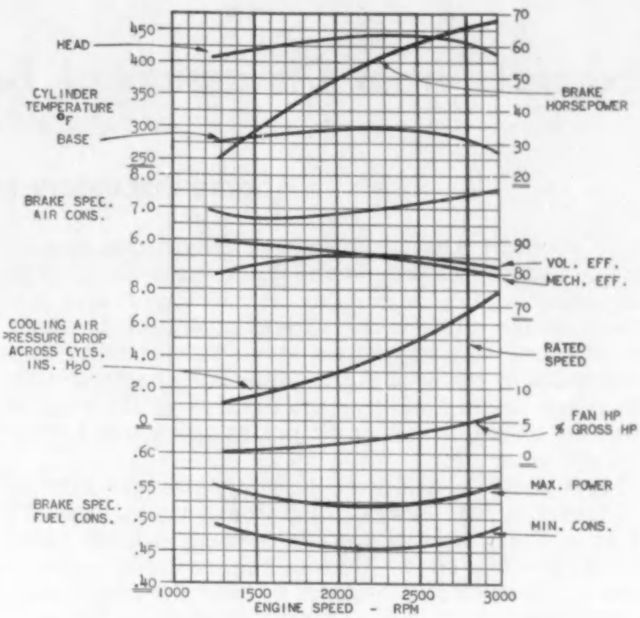


Fig. 4—Performance of 149-cu-in. cylinder at full throttle

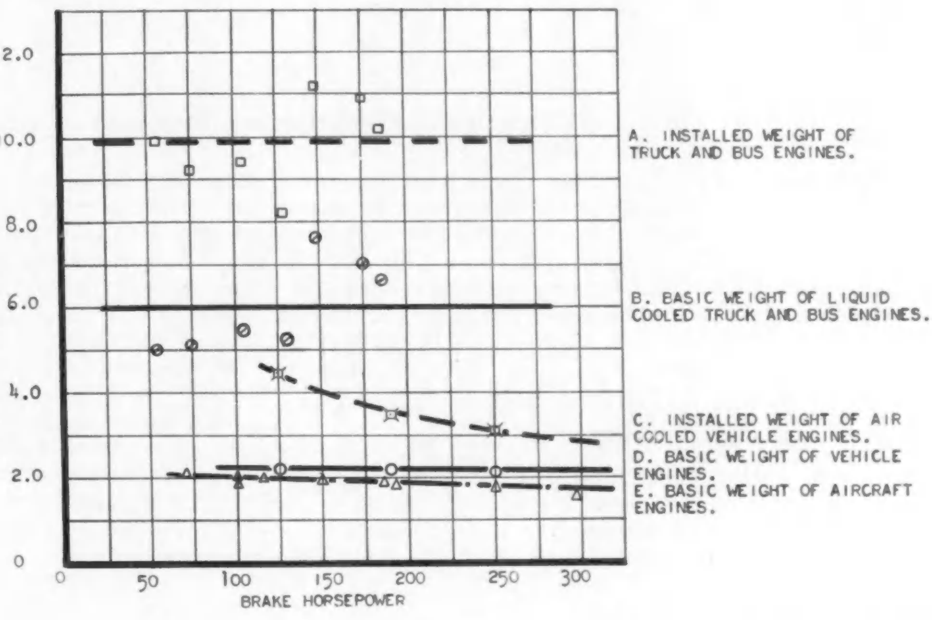
attains a given fuel economy and power output at a lower compression ratio than the liquid-cooled engine.

6. Antidetonation Qualities—Detonation is about equally severe in the two engines for equal power output, although the aircooled engine will probably have lower compression ratio.

The one count on which aircooled engines bow to liquid-cooled engines is temperature of cooling air leaving the engine. Cooling air leaving aircooled engines is much hotter. But this is not a serious handicap. Some installations may require additional temperature insulation for passenger comfort; others, already heat- and sound-protected, will require no additional insulation.

(Please turn to p. 22)

Fig. 5—Comparison of weights of aircooled and liquid-cooled engines



Excerpts from Discussion of Bachle Paper

Some discussors favor aircooling . . .

In general, the aircooled passenger-car engine meets the perfomance of the liquid-cooled engine in all respects, except possibly at the low end of the speed range. (Here the aircooled engine is much more prone to ping with a given valve timing and compression ratio—a fault sometimes corrected by delaying closing of the inlet valve slightly with small decrease in power output at the lower end of the speed range.)

Most people recall aircooling in passenger cars as evidenced in the Franklin cars built up to 1935. It is true that those automobiles were noisier than those having conventional liquid-cooled powerplants. However, if we were to take the experience gained since in building aircooled engines for airplanes, helicopters, and Army tanks. and add it to the production experience which industry has had in building the enbloc type of water-cooled powerplants, I am sure that everyone would have an entirely different opinion of the aircooled engine.

It has been my experience that an engine having an aluminum crankcase on which are mounted individual cylinders would not be satisfactory from a silence standpoint, nor would it present the smoothness demanded by the motoring public today. The aluminum crankcase, of course, expands when heated considerably more than the cast-iron crankcase, with the results that bearing clearances are materially increased. Furthermore, the aluminum crankcase tends to act more as a sounding board than the cast-iron crankcase, with the result that noises are amplified.

For rigidity, it is best to cast the cylinders integral with the crankcase using, in a 6-cyl engine, 7 main bearings and in the V-8 engine, 5 main bearings. . . .

Experience with a 322-cu-in. straight-8 automobile engine built approximately 15 years ago showed the practicality of the enbloc type of design. This engine utilized the cast-iron block integral with the crankcase and cooled just as well as a similar engine built with individual cylinders.

It has always been argued that the aircooled engine is much more costly to build than the liquid-cooled engine. But a recent analysis on a 150-cu-in. engine of 3-in. bore and 3½-in. stroke showed a material cost differential of only 14¢ more for the aircooled engine. . . . From a labor standpoint, there was little difference between the cost to produce the overhead-valve liquid-cooled engine and the overhead-valve aircooled engine.

—**C. T. DOMAN**, Aircooled Motors, Inc.

Many commercial vehicles need more power to obtain acceptable acceleration and hill-climbing characteristics. There is seldom enough space available for a larger powerplant. The greater power available in an aircooled unit of a given size seems a logical answer.

In an experimental installation of an aircooled engine in a bus we have found that for the same bulk of engine, the aircooled engine delivers approximately twice as much power to the bus wheels as the original liquid-cooled engine did. The road performance of this bus, fully loaded, with aircooled engine installed is now comparable to the best modern passenger-car perfomance.

—**C. F. WIEGMAN**, Lycoming Div., AVCO Mfg. Corp.

Some discussors question advantages of aircooling . . .

The author's statement that there is a "freedom from plumbing troubles" is questionable. It must be admitted that much of the plumbing as such has been dispensed with, but a tinsmith—a plumber by another name—has taken over. Careful design and fabrication of ducts and baffles to prevent drumming and to provide proper air distribution is necessary in the aircooled design.

—**A. A. CATLIN**, International Harvester Co.

Will the many sheet metal pieces required to direct the flow of air present a serious problem if they are mutilated or damaged by a serviceman not fully aware of their importance? Can adequate air flow be maintained over a wide range of operating conditions? . . . Will the aircooled cylinder be more sensitive to such variables as fuel-air ratios, fuels with lower octane number than engine requirements, and fuels that tend to cause excessive deposits? . . . These are some of the questions that can be answered only by widespread usage.

Basically there is no good reason why the performance of the aircooled engine should be superior to the liquid-cooled. . . . Many present-day liquid-cooled engines were designed to give maximum torque at relatively low speeds and therefore suffer when compared with an engine designed for maximum torque at relatively high speed.

—**V. C. YOUNG**, Eaton Mfg. Co.

CAREFUL ASSEMBLY

Insures Impeller Balance

BASED ON PAPER* BY

T.S. McCrae

Assistant Director of Engineering
ALLISON DIVISION, GMC

(This paper will be printed in full in SAE Quarterly Transactions.)

HOW thorough assembly controls must be to insure uniformity and quality of gas turbine powerplant components can be seen from methods used for assembling the impeller of a centrifugal compressor now produced for turbojets.

Any distortion of the impeller assembly during engine operation would result in an out-of-balance condition sure to lead to serious engine vibration. So the greatest care is taken during assembling of the impeller to prevent possibility of distortion or shifting of the parts in service.

The impeller assembly used in the compressor of the Allison-produced turbojet looks like a double-faced version of those used in reciprocating-engine superchargers. Its five main parts are a forged-aluminum center section, two forged-aluminum inducers, and two hubs. The hubs provide for bearings and oil slingers. Fig. 1 is an exploded view of all parts in the assembly.

Throughbolts hold the five main parts together. Hollow dowels, dowel holes, and closely held pilot diameters maintain correct relative positions between center section and inducers.

The center section is finish-machined all over except for dowel holes and pilot diameters. Next the piece undergoes preliminary balancing. Then it is spun in an evacuated chamber at a speed well above its operational maximum. This spinning allows the piece to do what stretching it is going to do, before it operates in the engine.

Comparison of OD measurements taken before and after spinning indicates in general the quality of the forging. (Ultrasonic methods used earlier in the processing determine certain specific quality characteristics.)

Parts shown to be satisfactory by the spinning are ready for final machining of dowel holes and pilot diameters, since it can be assumed that permanent stretch has taken place and critical diameters will not distort during engine operation.

The inducers go through similar steps. They are

* Paper "Production Problems of Turbojet Engines" was presented at SAE Annual Meeting, Detroit, Jan. 12, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

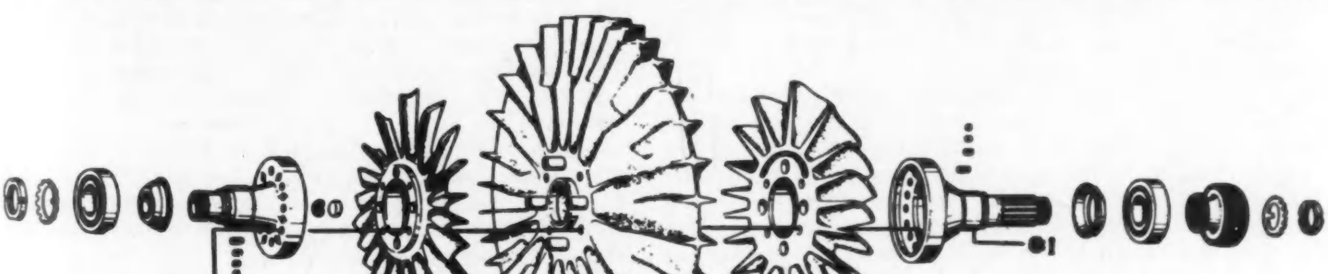


Fig. 1.—Exploded view of impeller assembly

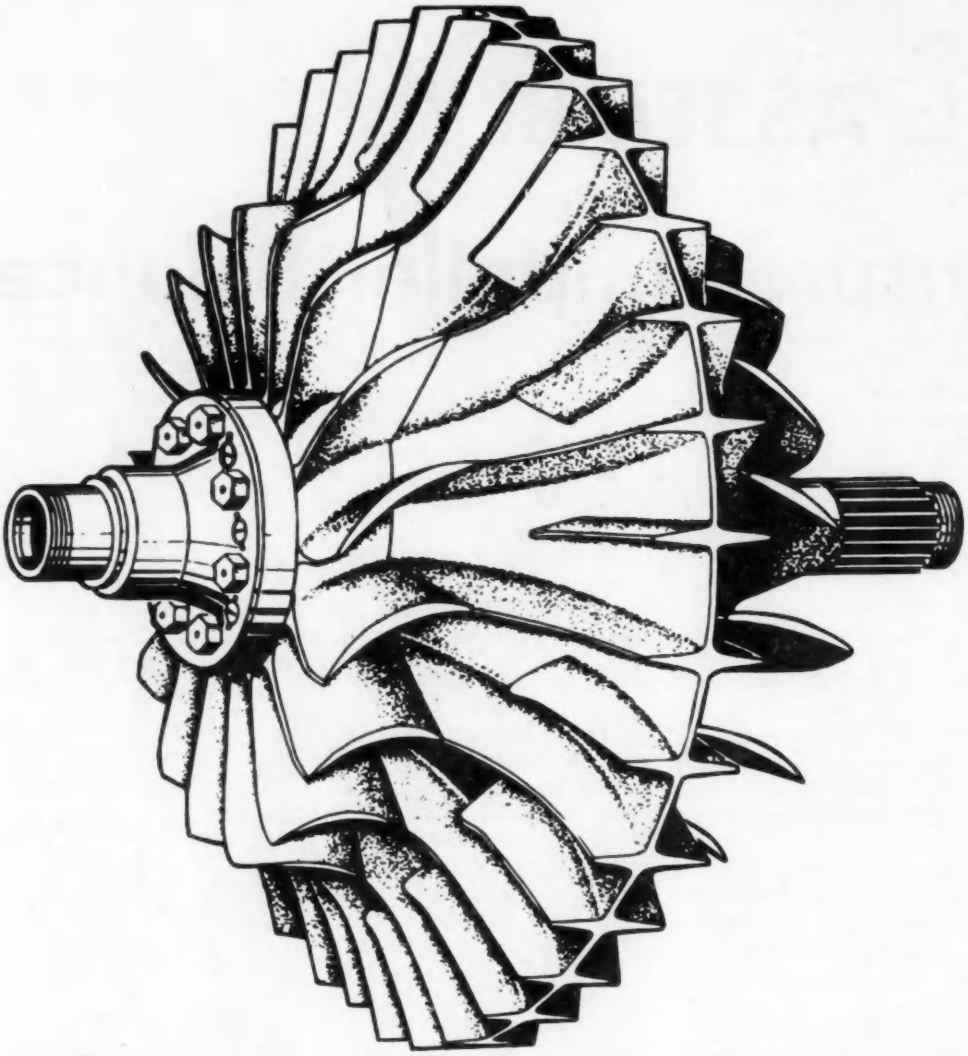


Fig. 2.—Impeller assembly

partly machined, then balanced and spun, and finally finish-machined on dowels and pilot diameters.

The steel hubs do not acquire a permanent set during operation, so they do not require balancing as detail parts. Hubs are completely finished in the conventional manner.

When machining is completed, the assembly is built up with inducers dowelled to the center section and hubs piloting on inducers. Fig. 2 shows how the assembled parts appear.

After a preliminary seating operation, the assembly goes into a fixture which holds the center section stationary and applies to the hubs torque equivalent to the torque load when 4000 hp is applied to run the compressor. (The same torque is applied to the hub which will transmit power to the accessories, as to the other hub, because the accessories take off only a relatively small amount.)

With the assembly up in the direction it will wind during actual operation, the throughbolts are tightened.

Next the assembly is spun at a speed above the highest engine operating speed, yet below the speed at which the center section was first spun. Any shifting due to centrifugal forces takes place during this spinning.

Now that possibilities of distortion or shifting during operation have been eliminated as far as possible, the assembly is ready for final dynamic balancing. Balance is achieved by screwing plugs of different weights into threaded holes in the hubs. When balance is as near perfection as is practical to go by installing plugs, stock is removed from the sides of the vanes to whittle the remaining unbalance down to within ounce-inches of true balance.

Vibration pickups attached adjacent to the compressor section of the completed engine during production testing attest that this impeller assembly method achieves its aim. Vibration is almost always within the small limits allowed.

The care evidenced by these impeller assembly procedures exemplifies the thoroughness required in all materials specifications, processing controls, operations sheets, assembly specifications, and inspection procedures to insure uniformity and quality of all gas turbine powerplant units.

Selection of Steel for Automobile Parts

What Engineers Should Know Today About Hardenability-Band Steels

Part II—Significance of Hardness

This is the second of a six-part report issued by the SAE Iron & Steel Technical Committee that is appearing serially in succeeding issues of the SAE Journal. The series started in the August issue. This report was prepared at the request of the SAE Iron & Steel Technical Committee's Division XVIII, Hardenability Publications. Part I was prepared by Joseph Geschelin, Chilton Co., from material provided by the Committee's Division III, Hardenability Bands. Parts II-VI were prepared for the Division by A. L. Boegehold, Research Laboratories Division, GMC.

STEEL in automobile parts is required to satisfy quite a variety of manufacturing procedures and service conditions. The demands arising from processing are all derived from the desire to keep the cost of the article at a minimum. In most cases the lowest cost steel that will meet service requirements will result in the lowest cost finished part. In some cases a slightly higher cost steel may result in a lower net cost because it machines easier, forges with less die wear, or distorts less.

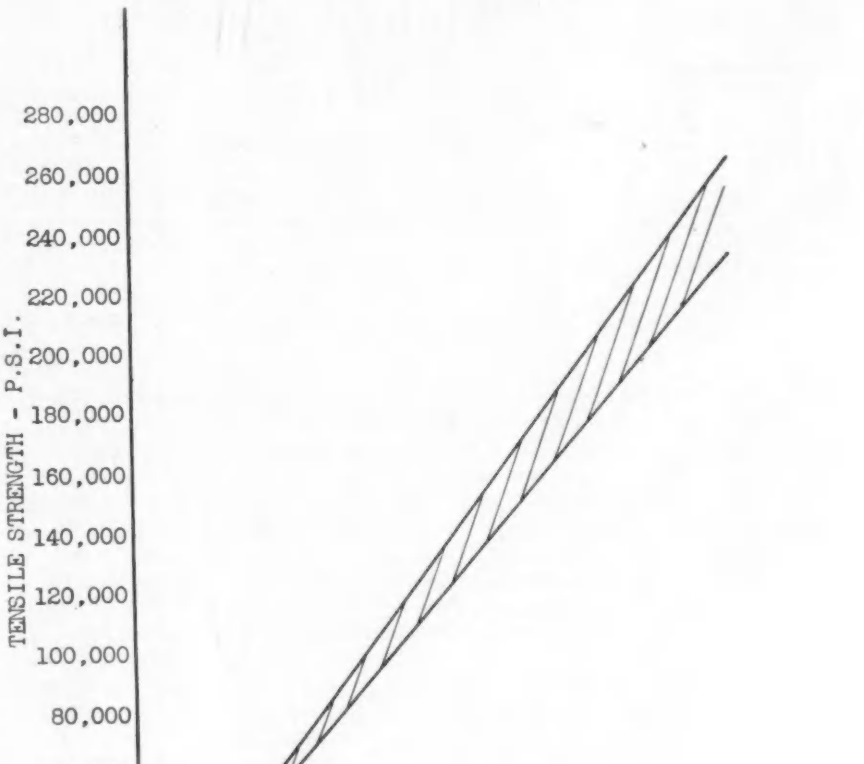


Fig. 1—Summary of data on carbon and alloy steels, including series 1000, 1300, 3100, 3200, 4100, 2300, 4600, 5100, and 6100 in hardened and tempered, as-rolled, annealed and normalized conditions

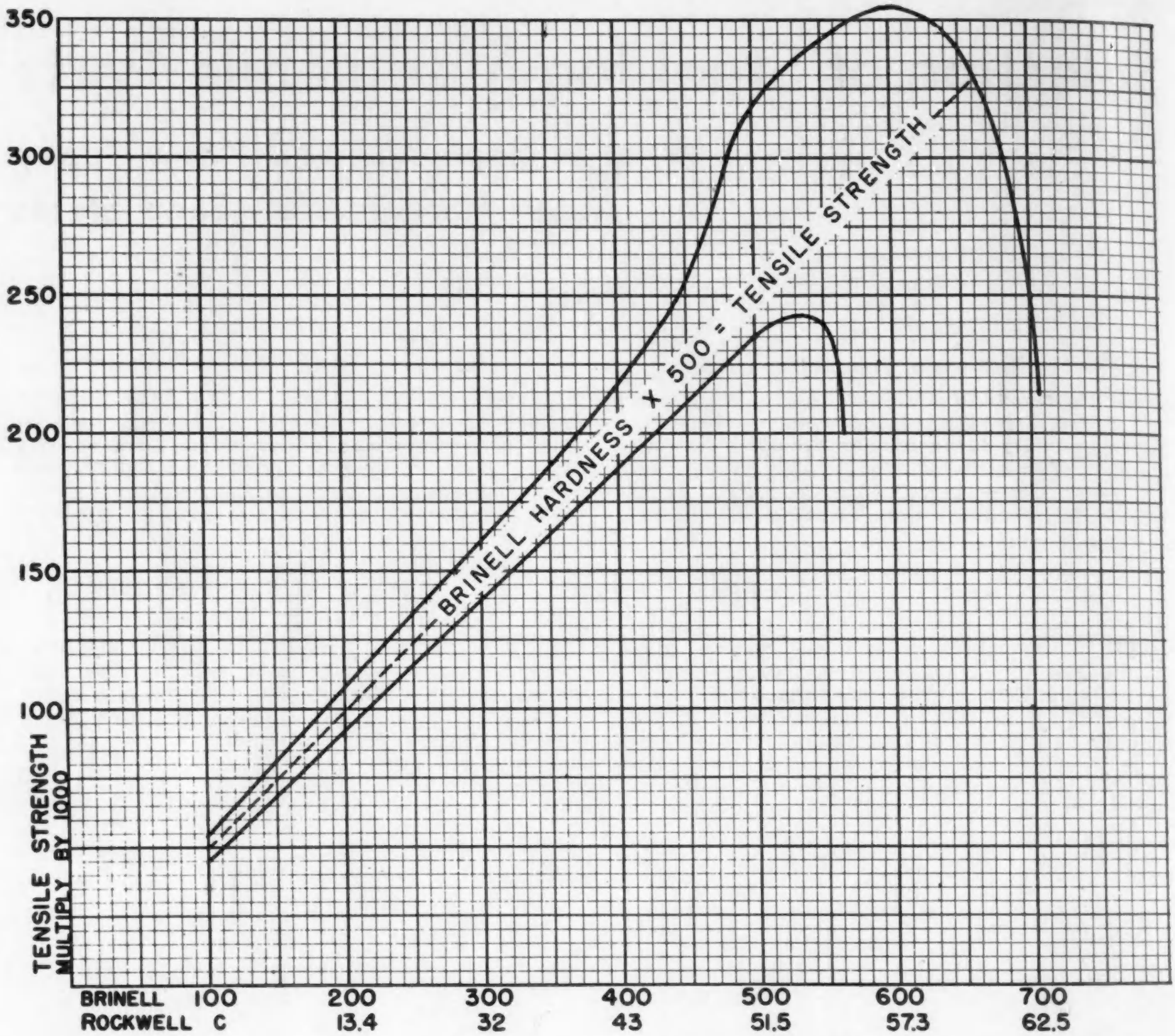


Fig. 2—Data of Fig. 1 extended to 750 Brinell (63 Rockwell)

These processing characteristics are determined by cut and try where previous experience has not classified the materials. This discussion, however, is not concerned with processing characteristics.

The first requirement made of steel is that it be capable of developing physical characteristics necessary for successful functioning of the part, made of that steel. Up until about 10 years ago, suitability of steels for meeting service conditions was also a matter of experience or determination by cut-and-try methods—the same as used for determining processing characteristics.

Going back many years, engineers and metallurgists had established the hardness needed in various automobile parts for successful operation, and steels were found which would produce the desired hardness in each part. In the meantime, we have learned a lot about how to obtain the hardness desired so that now the steels used are, in many instances, quite different in composition; but the hardnesses of the different parts have not changed very much.

In general, the procedure used in arriving at the size and hardness of car parts has been to first decide on the dimensions to obtain the desired amount of stiffness or flexibility, as the case may be, and then to give the part as low a hardness as will result in satisfactory service. The lowest hardness is desired to aid in machining the part to size. Those parts that fail at the lowest hardness are made harder and harder until they do not fail. When the hardness to insure freedom from failure exceeds 36 Rockwell C in most steels, it becomes advisable to do the machining before hardening and tempering. In the case of 4340 steel, machining can be performed up to 44 Rockwell C.

The reason hardness is increased when more strength is required is because strength is directly proportional to Brinell hardness, at least up to 500 Brinell. This applies to all ferritic steels in all con-

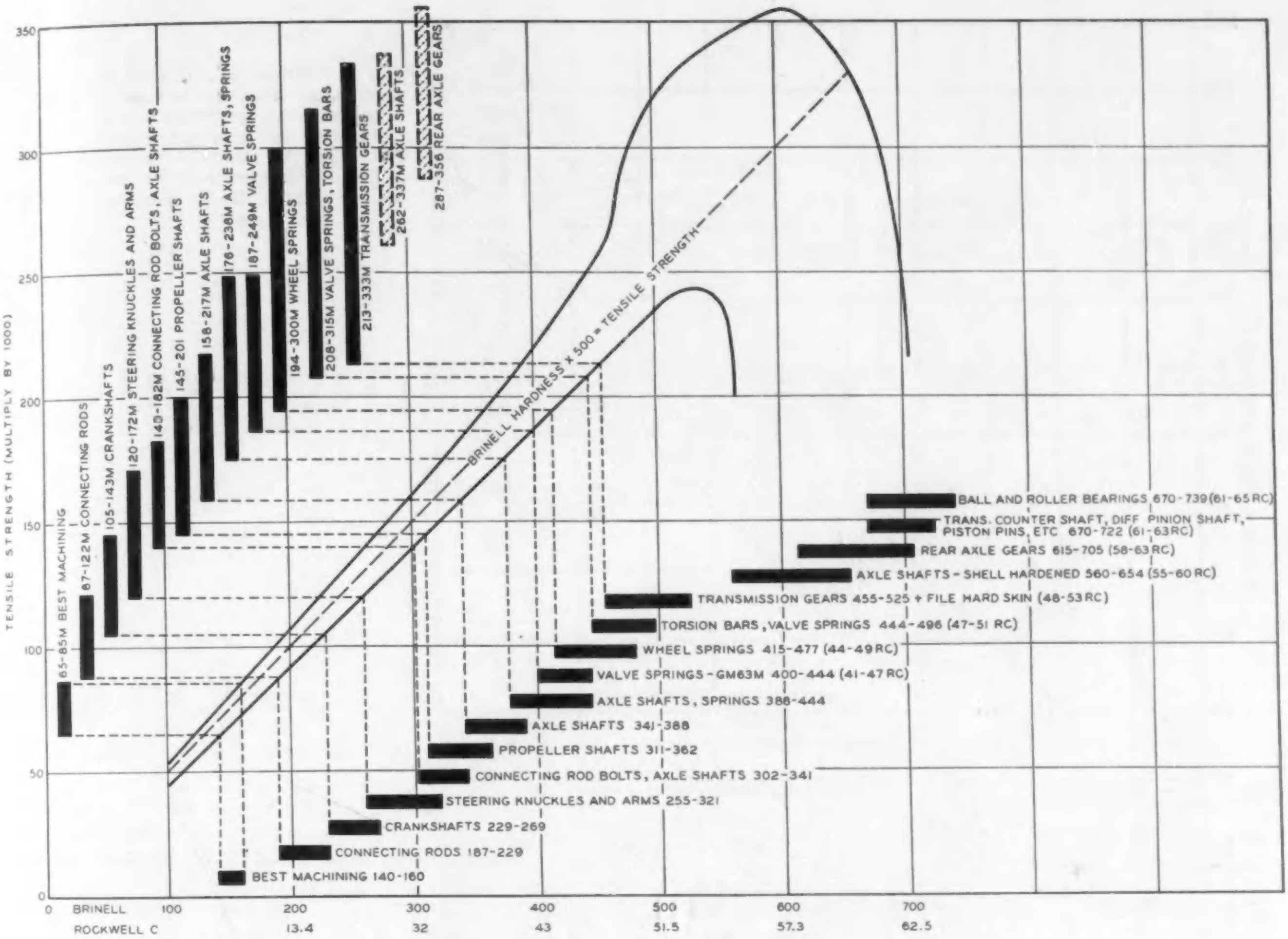


Fig. 3—Hardness limits for important car components superimposed on Fig. 2

ditions, whether resulting from hardening and tempering or from annealing.

A survey of all the commonly used plain carbon and alloy steels, made by the writer about 1937 for the G. M. Metallurgical Committee, resulted in a chart shown in Fig. 1. This is one of a group prepared at that time and which now appears in both the G. M. Standards and the SAE Handbook. It shows the way hardness and strength increase together up to 500 Brinell. If the plot is extended up to 750 Brinell (63 Rockwell) using data collected during the war, we have the situation shown in Fig. 2. The lack of apparent relationship between strength and Brinell hardness is presumably caused by residual stresses.

In the greater portion of cases these residual stresses are in the same direction as applied loads used to measure the strength of the material; therefore, they make the apparent strength lower than that expected from the law of 500 times Brinell hardness equals tensile strength, established at lower hardness levels.

When residual stresses are in opposite direction to those from test loads, the apparent strength is above the theoretical. As an example, at 56 Rockwell C, which is 600 Brinell, we should have 300,000 psi tensile strength; but we have obtained as high as 350,000 psi. Now if we superimpose on this chart typical hardness limits specified for various important automobile components, we get a picture in Fig. 3 of the strength they possess, which is in most cases, proportional to the amount of stress imposed in service.

Axle shafts are shown at four different hardness levels. Shafts used with only 302 to 341 Brinell hardness are relatively light duty. At 341 to 388 Brinell and 388 to 444 Brinell, we have axles subjected to heavier loads. Very heavy duty shafts are listed at 55 to 60 Rockwell. These shafts have a soft center and are referred to as shell hardened axles. More will be said about these later.

Rear axle gears and transmission gears are shown at the top of the hardness range. It is obvious that in this range care must be exercised to use treatments that will set up favorable residual stresses in the high hardness material; otherwise strength would be lacking.

The relation between strength of steel and stress that can be imposed in service without premature failure is pictured in a general way in Fig. 4. Members having smooth surfaces without notches may be stressed to about one-half the tensile strength—complete reversal of stress per cycle occurs.

When stress is applied in only one direction, as in a coil spring, the maximum load may be much higher—approaching the elastic limit when the

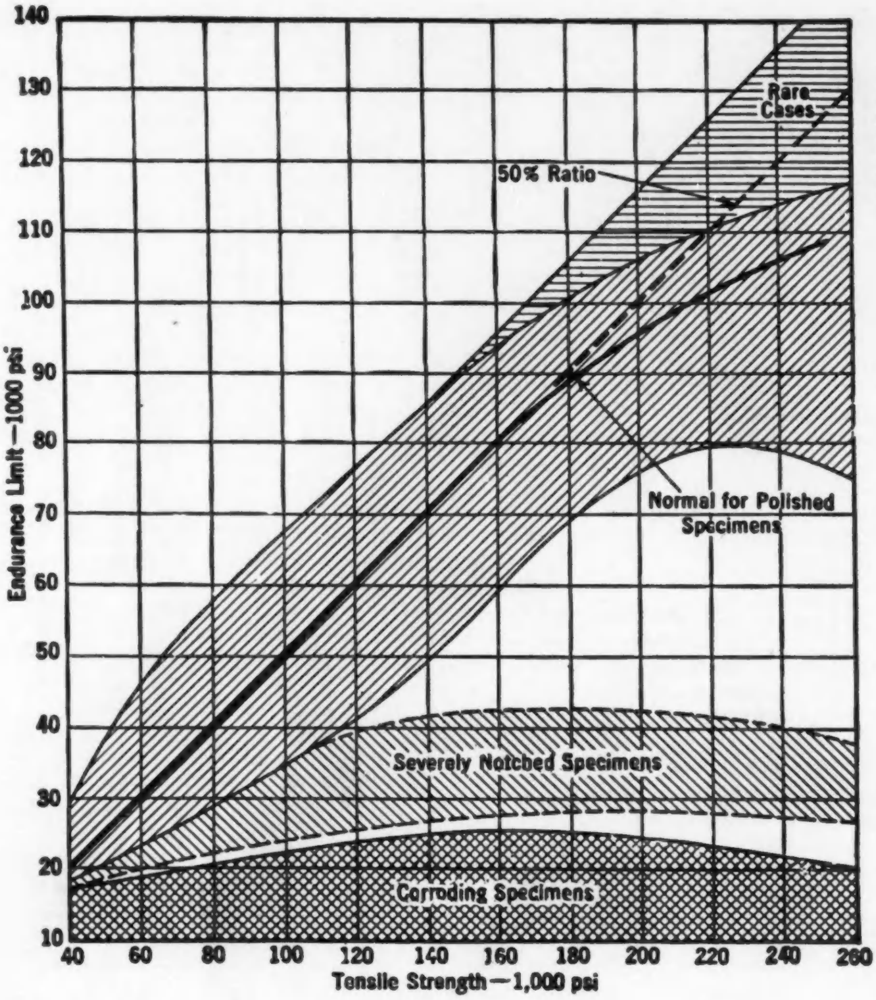


Fig. 4—Relationship of strength of steel and stress that can be imposed in service without premature failure. These data were prepared in 1941 by the Battelle Memorial Institute in a report "Prevention of the Failure of Metals Under Repeated Stress"

range of stress decreases by increasing the minimum stress. Articles of irregular shape, like steering knuckles, must be stressed at much lower levels (represented by the band labeled "severely notched specimens"), or at stresses intermediate between 50% of tensile and this band, depending on the severity of the notch.

Members subject to corrosion must be limited to much lower stresses, for example, like a steering arm. Stress in such members is represented by the band labeled "corroding specimens." As an example, consider the case of a certain steering arm. By means of SR-4 strain gages, surface stresses during operation were measured between 25,000 and 30,000 psi. The steel is supposed to have a minimum strength of 120,000 psi. Even at the low stress recorded, premature failures were experienced.

This was attributed to a combination of notches due to rough forging surface, and inexpert hand grinding the surface, and also to corrosion. In addition, decarburization may exist at the surface which always greatly decreases the permissible stress for operating without failure.

It will be seen by a second look at Fig. 3 that all car members are heat-treated to hardnesses well above the range of good machinability. Machining is done after heat-treating on all parts having hardness below 38-40 RC. On those parts that must have hardness too high to machine, the parts are annealed, machined, and then hardened. The machining cost, therefore, is low compared to that when machining is done after hardening.

The reason given for machining after hardening is that accuracy is obtained which could not be obtained if hardening were done after machining. Since, however, hardening follows machining in some parts where accuracy is required, it would seem reasonable to take advantage of the cost saving by hardening all parts after machining steel in the annealed condition only. The extra routing and special heat treatments necessary to do this tend to cancel out the saving that might be expected.

ROCKETS and INTERPLANETARY TRAVEL

EXCERPTS FROM PAPER* BY

Dr. Gerald Wendt

Formerly Editorial Director, "Science Illustrated"

WHAT are the actual prospects for traversing space beyond the limits of the earth's atmosphere?

To do so, two real difficulties must be overcome. The first is command of the actual principles and the engineering involved. This is relatively simple. The second is much harder. It is psychological. It involves readjustment of one's thinking and point of view, overcoming our natural earth-mindedness and even air-mindedness and becoming space-minded or cosmic-minded.

Escaping from the earth and the air—just psychologically, for the present—involves acquiring a conviction, not just intellectually, but emotionally and spiritually, that the earth is just a small globe spinning on its axis, and gliding unsupported through space, somehow making a circuit around the sun once a year. We must automatically look at it like that—from the outside, from space, not from a spot on the surface.

It requires also a new sense of what speed is, so that high velocities seem normal—as indeed they are. The earth rotates once in 24 hr. At the equator this means a speed of 25,000 miles in 24 hr, which is more than 1000 mph or 17 mpm.

The first problem is how to get off the earth. Aviation had already taken the first step—but even that began only 45 years ago. Planes leave the surface but they are still immersed in the surrounding air, like fish in the ocean.

But to rise above the air itself, to dispense with the air both as a supporting medium and for the combustion of fuel involves two further steps. The first is a motor that does not push against anything, that has no supports or wheels or propellers but operates purely by recoil, that is completely independent of all the rest of the universe. The second requirement is that this motor must be very light so that it can propel many times its own weight. This is the rocket or "reaction motor."

A good modern automobile engine weighs about 800 lb for 160 hp—about 5 lb per hp. For comparison a modern airplane engine weighs about a ton and delivers 2000 hp—one lb per hp. That is the difference between wheeling and flying. But the rocket motor in the V-2 weighs about 1000 lb and generates 600,000 hp—one lb for 600 hp. That is the difference between flying and rocketing. In other words, 1000 lb of automobile engine gives 200 hp. In the aviation engine it gives 1000 hp. In the rocket it gives 600,000 hp.

Principles of Rocketry

The reaction motor operates by recoil exactly like a gun. In the explosion of a shell the amount of motion, or inertia, imparted to the gun itself is exactly equal to that imparted to the bullet or shell. The product of mass times velocity is the same for each $MV = mv$. The thrust which pushes the gun in one direction—or, in other cases pushes the jet plane or the rocket—is equal to the mass of the material propelled out of the mouth of the nozzle times its velocity. In a reaction motor which operates continuously, the thrust is equal to the velocity of the exhaust gases times the mass of material expelled per second $P = V\frac{dm}{dt}$. This is all that matters.

The rocket does not "push" against the air—or against anything else. If the motor is immersed in air, the chief effect of the air is to slow down the

* Paper "The Space Ship and the Man-Made Moon" was presented at SAE Summer Meeting, French Lick, Ind., June 5, 1949.

velocity of the exhaust and thus to reduce the thrust. Power is wasted in churning the air. The motor is efficient only when there is no air, hence in outer space or in the thin upper atmosphere. Rockets have the great advantage that they have no moving parts and thus waste no power in friction.

Since the purpose of the motor is to drive the rocket forward and since the motion of the rocket builds up continuously even with a steady velocity of the exhaust gases, the peak of efficiency is not reached until the rocket itself is moving forward, relative to the earth, at the same speed at which the exhaust gases emerge. At that time, the emerging exhaust gases will, in effect, stand still relative to the earth and all the motion goes to the rocket. Consequently the reaction motor and the rocket are justified only at high altitudes and at high velocities. In modern reaction motors, the velocity of the exhaust gases is 5000 to 8000 ft per sec. At such speeds rockets can rise so high that they leave 99% at the atmosphere beneath them.

It is important for the understanding of rocket flight to remember that about 79.5% of the mass of the atmosphere is in the troposphere which extends about 10 miles up at the equator, about five miles at the poles. It contains nearly all the clouds and weather and is the medium for ordinary flight. Above it the stratosphere extends to about 50 miles from the earth's surface. It contains another 20% of the air mass. Thus at only 50 miles up about 99½% of the air mass is below. But the ionosphere extends for some 2000 miles beyond that, though it contains only ½ of 1% of the air mass. It is ten million times rarer than the air at the earth's surface, and is indeed a better vacuum that has even been attained in the laboratory. This is the present area of rocket performance. Obviously a rocket must carry its own oxygen as well as fuel.

Thrust could be increased either by ejecting more mass or by using a higher exhaust velocity. Obviously it must be the velocity that is increased and this can be done by concentrating energy in the fuel. Therefore, the fuels used are much more concentrated in energy than are ordinary explosives.

One of the major advantages of liquid fuels is that until they are sent into the combustion chamber they can be carried in comparatively light tanks and thus greatly reduce the weight of the rocket. It is now possible to work to a practical standard of one pound of payload for every two pounds of rocket structure plus six pounds of fuel. These are present high-altitude rockets.

They go effectively beyond the atmosphere; but they do not escape from the earth in the sense of escaping from its gravitational pull. Yet if a rocket could rise high enough it could do that too, for the earth's gravitational force dies out with distance. It is reduced proportionally to the square of the distance from the earth's center. Thus at 4000 miles up an object would be twice as far from the center of the earth as it is at the surface and would weigh one-fourth as much (since 2×2 is 4). An object that weighs four pounds at sea level would weigh only one pound at an altitude of 4000 miles. at 12,000 miles it would weigh only a quarter of a pound and at 28,000 miles an ounce. No object can ever get quite beyond gravity because, theoretically, gravity goes on forever. But because gravity steadily gets less it is possible for an object to travel upward so fast that any decrease in speed caused by gravity would always be less than the decrease in gravity itself. That velocity is 6.85 mps, or about 37,000 fps. Once that speed, the escape velocity or liberation velocity, is attained, the object would be lost to earth and would continue into outer space.

But an exhaust velocity of that size from the rocket motor is far beyond any present achievement or even beyond any immediate hope. Velocities of 7000 to 8000 fps have been attained and it is quite possible that speeds of 10,000 or even 12,000 fps will be attained within the next few years. But that would require an efficiency of at least 85% in using the energy content of gasoline and liquid oxygen. Therefore, to attain an exhaust velocity of 37,000 fps will require a much more concentrated source of energy than can be had from chemical fuels. This probably means that escape from the earth's gravity will not be possible until the much greater energy concentration of atomic or nuclear fuels can be utilized. This does not mean that escape from the

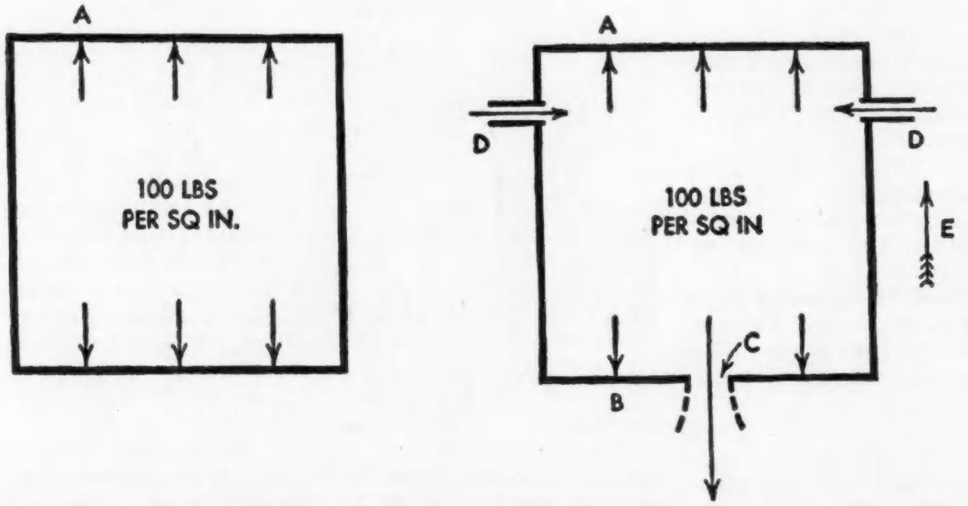


Fig. 1—Simplified thrust diagrams. An opening on sq in. in area gives a net upward pressure on the chamber of 100 lb, provided the original pressure is maintained within the chamber in spite of the opening. (Courtesy G. Edward Pendray)

earth is impossible or even that it must be long delayed. The atomic bomb uses that energy now. It was created and used within three years. The combination of nuclear power research with rocket research may make the escape velocity available within the near future, though—so far as is known on this side of the secrecy wall—it is not even being studied now.

To relate the present to the future I want to list 10 different stages in this field of research and engineering. They are:

1. The gas turbine.
2. Jet planes.
3. Rocket-assisted planes.
4. Rocket missiles.
5. High-altitude rockets.
6. Space missiles.
7. The island in space or man-made moon.
8. Interplanetary travel.
9. Reconstruction of the solar system.
10. Exploration of the universe.

These are 10 logical steps in the development of jet propulsion. The first five of them are actualities that came from nothing in the past 10 years. The next two are commonplace items in today's engineering. The sixth is on the verge of accomplishment. Only the last four remain in the future.

Rockets that can travel hundreds or even thousands of miles are at present the major field of rocket study. They are sufficiently successful to make very real the possibility of long-range bombardments in the future war and the possibility of transcontinental and transoceanic transit of mail or express even before that war, at speeds of 1000 mph and upward to perhaps 5000 mph.

But passenger flight by rockets is quite another matter. I shall take the liberty of quoting a few thoughts from G. Edward Pendray's recent book, "The Coming Age of Rocket Power," on this phase of the subject:

"The probabilities are that passengers will not be traveling in rockets until after these projectiles have been fully developed for carrying mail and express. The minimum requirement for a human passenger would be an enclosed cell supplied with air at about sea level pressure, continually enriched with oxygen and free of carbon dioxide. The passenger would also need some shock absorbing equipment in case of hard landing. He would need to lie down on a spring-mounted hammock. He would depend entirely on the automatic steering gear of the rocket; it would be out of the question for him to have any control over these functions—a human pilot's reflexes would be too slow and erratic. He would be able to see little. On the upward part of the trip he would perhaps catch a vague glimpse of the ground rapidly receding from him. Clouds and mists of the upper stratosphere would soon obscure the familiar features of the earth. In the stratosphere the world would be completely buried in haze; the glare of the sun would hurt his eyes. The first passenger will spend a cramped and terrifying few minutes far above the earth. Very likely he will be glad enough when it is over.

"At a jet velocity of 8000 fps, we can design a single-step rocket that could fly 400 miles—say from New York to Pittsburgh. If it is to carry a ton of payload the structure will weigh two tons and the fuel six tons, a total of nine tons. This would permit the weight of a pilot and four passengers.

The fuel, liquid oxygen and acetylene, or gasoline, at 20¢ per gal (2.5¢ per lb) would cost $300—$75 a passenger. Adding all the other costs of operation, maintenance and management, "it seems safe to guess that the cost of a ticket from New York to Pittsburgh would come to $300 or $400 at the least." Since an airplane ticket comes to only $25.01 "this is rather a steep price to pay for saving, at the most, two hours in travel time."

Speed itself is not important since we are now actually moving around the sun at a velocity of almost 19 mps and are not even aware of it. What does affect the human body is the change in the rate of speed, which is acceleration.

"We may safely conclude," Pendray continues, "that the maximum practical average acceleration permissible to a passenger-carrying rocket would be about three or four times gravity, or 96 to 128 fps per sec.

"Of course, acceleration is not the whole story. The psychological difficulties encountered in rocket flight might well be less easy for the passenger to take than the physical ones.

"The rocket is accelerated for only a brief part of its journey—the first minute or two will be quite enough, at 3 G's, to provide the velocity needed. The fuel having by this time been expended, the motors will cease operation. Instantly the passengers will pass over from a condition of accelerated flight, in which their normal weight will appear to have been multipiled three or four times, to a condition the physicists call free fall, in which they will seem to weigh nothing at all.

"For the state of weightlessness is approached in human experience only in falling. There may ac-

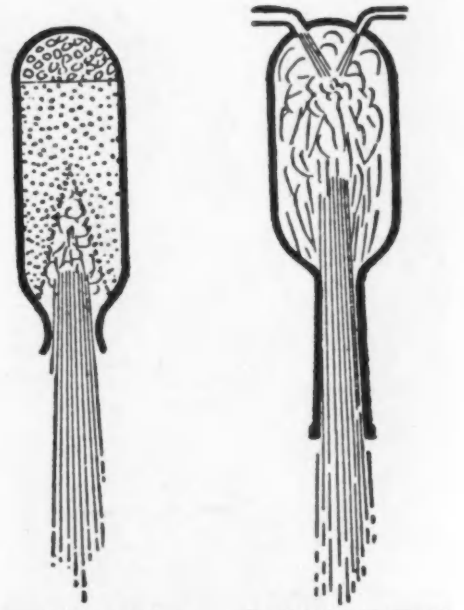


Fig. 2—Two types of true rocket motors. (Courtesy G. Edward Pendray)

company this experience in flight an emotion of intense terror. Most of us are mortally afraid of falling.

"These sensations accompanying free fall will be matched by some other queer experiences. Since everything in the rocket ship is in free fall with it, none of the objects riding with the passenger will appear to have weight either. Assuming that the passenger is hungry, and food is available, he will find it out of the question to eat solids from open plates, or move them to the mouth in ordinary spoons or forks. When pushed or disturbed in any way, food will simply float away in the direction of the push. Liquids in open containers will be impossible to drink. A glassful of water would float up out of the glass in a round globule.

"The passengers will have to be strapped to bunks or hammocks. If they attempt to walk about during the period of free fall, they will very likely bump their heads against the ceiling."

Just for contrast I want to return you now to the practical level of the engineer. On the actual status of all the research I quote R. W. Porter, of the Aeronautic & Ordnance Systems Divisions, Apparatus Department, General Electric Co.:

"Theoretical values of specific impulse have been calculated for most of the interesting propellant combinations. Tests show that we can expect to obtain at least 90% of this performance in practical motors. Experience in making and handling propellant materials is being accumulated rapidly, especially in the case of liquid hydrogen, metallic hydrides, fluorine, and hydrazine.

"Test facilities have been built capable of testing rocket motors many times larger than the V-2. Because of the terrific temperatures involved, the matter of heat transfer is vitally important, and here too, some progress is being made, both in understanding the phenomena and in designing the motor so it will run cool.

"Information about the performance of electronics equipment under missile flight conditions, and about the nature of the upper atmosphere, is being gathered by frequent flights of the German V-2's, Aerobees, and other test vehicles. At least half a dozen sizeable supersonic wind tunnels will go into operation this year, and we will begin to use new mathematical machines capable of handling the complicated equations of missile flight dynamics.

"Yes, we're really getting started. But it will be a long time before a rocket engine can be designed from a handbook like a motor-generator, or a supersonic missile with the certainty of a radio set."

That's where we are now. In the last five steps of our list, we pass from actualities into what are presently impossibilities. As soon as exhaust velocities of seven miles a second are attainable, small missiles can be thrown into space, perhaps sent out from a high rocket by detonation of its warhead at the top of its path, as proposed by Dr. Fritz Zwicky. They could escape from the earth entirely to wander in outer space and probably to be attracted inward by the sun. At our distance from the sun, the sun's gravitational field is still enormous. No object, even after escape from the earth, could escape from the sun, from the solar system, until it attained a velocity of 26.2 mps—the sun's escape velocity.

But such particles need not escape entirely from the earth. Many of them could have sufficient sideways velocity, parallel to the earth's surface, so that their centrifugal force would balance the pull of gravity and they would circulate in orbits around the earth exactly as the moon does. If they could be givin such a horizontal velocity by the explosion of a warhead, they would not return to the earth's surface even though they had less than the full escape velocity. Therefore, small satellites could be established in the space close to the earth even before it becomes possible to leave the earth altogther.

How near this phase is may be judged from a quotation from a paper on "Morphological Astronomy" by Zwicky.

"The possibility of some rudimentary form of experimentation with the members of the planetary system has existed for some time by using radio waves and radar. The general possibilities have been greatly enhanced through the availability, brought about as a result of World War II, of rockets as carriers of scientific instrumentation. Much has already been done with V-2 rockets to observe conditions in the upper atmosphere and to get data on cosmic rays and the spectrum of the sun. In many ways the atmosphere remaining above the maximum height (200 km) of the V-2 is still very troublesome. For ultraviolet light, soft X-rays, atomic rays, and other messengers of space are still absorbed far too efficiently to be observable.

"The author, therefore, is working on rockets to reach 1000 km height. By means of secondary rockets to be launched from primary carrier rockets, this goal should not involve too many difficulties.

"In the second place, work is in progress to eject small test particles from the carrier rockets with velocities surpassing the velocity of escape from the

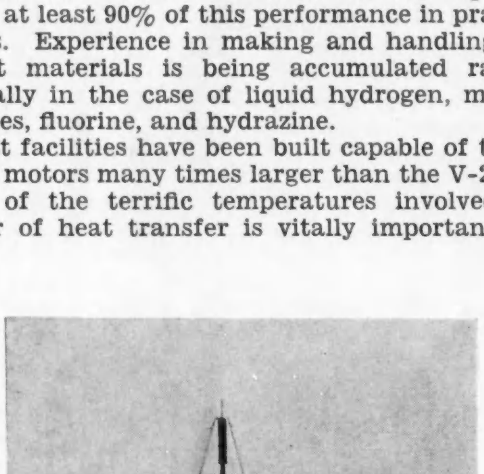


Fig. 3—The world's first liquid-fuel rocket and its designer, Dr. R. H. Goddard, taken just before the historical shot near Worcester, Mass. in 1926. (Courtesy G. Edward Pendray)

earth. Designs are being made, and have partly been realized to confer such velocities upon test bodies whose masses lie in the range from milligrams to one kilogram. With these bodies, the outskirts of the earth's atmosphere can be explored, hypersonic aerodynamics may be studied both in the Boltzmann and Smoluchowski regions of the åtmosphere, and a direct exploration of the electromagentic field around the earth appears possible. It is also hoped that the collisions of the test bodies with the moon and other planetary bodies can be observed and a new method of direct experimentation with these bodies can be established."

But we still have no "man-made moon." This will come when a full-sized rocket can be sent a few thousand miles up and can then be given a horizontal velocity and thus a centrifugal force that would keep it there.

After an island in space has been established it could be used to accumulate and assemble the parts of a major rocket for interplanetary travel. Since the force of gravity would be much reduced on such an island in space and there would be no air to get in the way, little additional force would be needed to start a voyage through space. Indeed, it would be difficult to avoid stepping off into space even with the slight power of human muscles. Thus a rocket assembled there could use all of its fuel for the long voyage through space, it would quickly achieve the escape velocity of seven miles per second, and thereafter, its flight would continue indefinitely by inertia without additional propulsion—unless the passengers were also interested in a return flight which would introduce additional problems.

Without such a satellite (or even with it) the problem of raising a payload to escape velocity is enormous.

I suspect that these two stages of rocket development—which I have called the man-made moon and the space ship are decades away. The first may come within 10 years, the second within 20. I should consider it more than probable that they both will have been accomplished and much improved beyond our present ability to imagine by the end of this century, by the year 2000 A.D.

But there remain two more steps in our list of 10. They deserve brief mention to complete the survey of present thinking. If we reach the planets, what shall we find there and what shall we do with them? Here I can do no better than to quote the serious fantasy of a British amateur astronomer, Olaf Stapledon. In the November 1948 issue of the Journal of the British Interplanetary Society, he wrote:

"Interplanetary travel should be possible within a few decades. Man should not only reach but land on other planets. Will he find inhabitants comparable to intelligent man? It seems unlikely. The moon is almost wholly without atmosphere and water, Mercury is far too hot on one side and far too cold on the other, Venus is more temperate, has atmosphere but lacks oxygen, may also lack water. Mars has lost most of its atmosphere and water, the asteroids are far too small, and the outer planets, Jupiter and Saturn are too big with the wrong kind of atmosphere.

"If the planets are uninhabited, what should be done with them? The first job is scientific exploration. If man has used his scientific knowledge to reconstruct our own world and unify the people then he can turn his productive attention to the other planets, not alone for economic expansion but as possible homes for man."

If this seems over-optimistic I shall return you once more to the redoubtable Dr. Zwicky of California Institute of Technology. I remind you that he is no amateur, that he is director of research for Aerojet Engineering Corp., which is making JATO rockets in huge quantities. In a recent lecture, he proposed nothing less than the "reconstruction of the solar system." If the planets such as Venus of Mars prove uninhabitable because of temperature conditions he would move them into other orbits, either nearer to the sun or farther out until the climate suited us, presumably using nuclear rockets. Thus their conditions could be so modified as to make them habitable.

Then just for the record, there is the final stage, which is quite unimaginable at present, when man will not be confined even to the solar system, when he can achieve exhaust velocities in his rockets faster than 26 mps and can thus defy not only the pull of the earth but even that of the sun and can wander about the limitless reaches of outer space, can approach the distant stars and—quite possibly—can find among them planets which are more to his liking than any of the satellites of the sun.

It is important to stress that the actual escape of rockets from the earth's gravitational pull is entirely impossible with present fuels and will require the perfection of atomic engines and their adaptation to rocket propulsion. Yet nuclear research has a way of leaning ahead in colossal jumps. So it seems altogether probable that the next two steps, the island in space, and interplanetary travel, can be taken within 20 years or certainly by the end of the century.

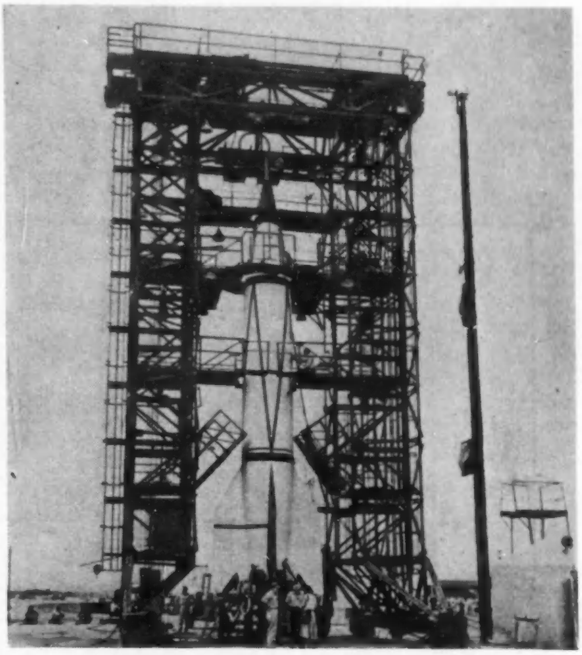


Fig. 4—The present rocket launching platform at White Sands, N. M. (National Military Establishment)

Table 1—Typical Inspection Data on Diesel Fuels Used in Test

Inspection	Conventional Fuel	Wide-Cut Fuel High Cetane Number, Low Sulfur
Viscosity @ 100 F, SUS	35	33
Pensky-Martens Flash Point	150 F	130 F
Cetane Number	50	50
Sulfur, % of weight	<0.5	<0.5
Distillation		
Initial Point	350 F	310 F
50% Point	510 F	490 F
90% Point	585 F	600 F
End Point	650 F	650 F
Heating Value		
Low, Btu/gal	128,800	127,500

WIDE-CUT

BASED ON PAPER* BY

A. B. Crampton

S. H. Hulse

and N. H. Rickles

Standard Oil Development Co.

WIDE-CUTTING techniques permit higher yields of diesel fuel without impairing its quality characteristics. Satisfactory performance of wide-cut diesel fuels was proved in a 15-month full-scale test in diesel-electric locomotives and was confirmed by laboratory tests on four automotive-type diesels.

Fig. 1.—Effect of wide cutting in the production of kerosene or diesel fuel

Wide-cutting makes it possible to extend supplies with the least degradation in cetane number and sulfur content. Advantages of this method are based on the interdependence of supplies of kerosene and high-quality diesel fuels. Both generally come from the same type of crude, but maximum yields of both cannot be produced by the refiner from the same center fraction.

When producing diesel fuel, nonmarketable light kerosene fractions also are derived. Producing kerosene leaves heavy diesel fuel fractions, which also present a problem. Fig. 1 graphically illustrates this fact and shows a schematic volatility comparison of a typical kerosene, a conventional diesel fuel, and a wide-cut diesel fuel.

* Paper "Wide-Cut Diesel Fuels," was presented at SAE Annual Meeting, Detroit, Jan. 13, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

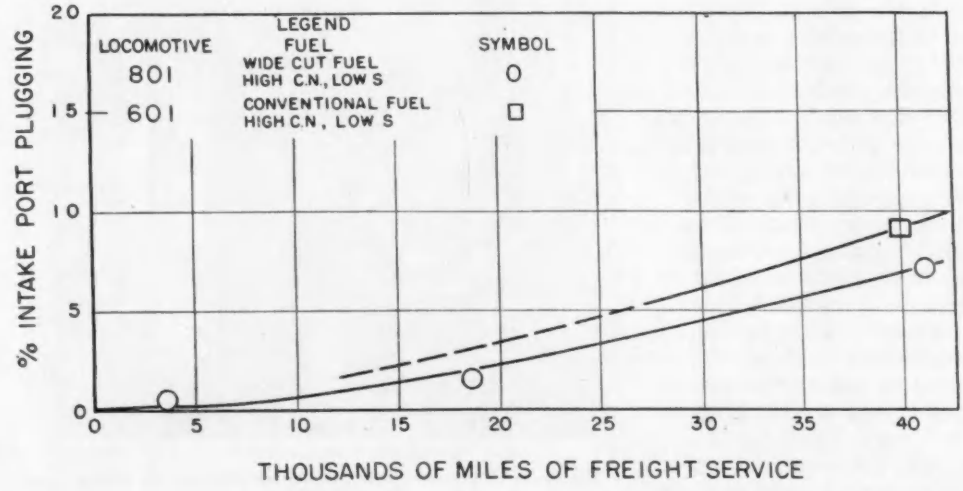


Fig. 2.—Performance of wide-cut and conventional diesel fuels compared in their effect on intake port plugging. These data are from tests on Electro-Motive F. T. diesel engines in freight service on the New York, Ontario, & Western Railway

DIESEL FUELS

Help Extend Refinery Output, Perform Well in Railway Tests

In effect, the kerosene is the coat and vest, the present diesel fuel the vest and pants. The wide-cut, 130 F flash fuel is the coat, vest, and pants—and broadens the coverage of diesel fuel supplies by using the light and heavy fractions not readily usable in conventional fuels. Its adoption would increase flexibility of refinery operations and permit unusually high diesel fuel yields when required.

Mixing kerosene and diesel fuel in the field does not produce an equivalent increase. The operation must be carried out in the refinery during the actual distillation process.

Tests on full-scale equipment on the New York, Ontario, and Western Railway demonstrated the quality of wide-cut fuels for use as railroad diesel fuels. The test locomotives were 2700-hp Electro-Motive F. T. diesels composed of two two-cycle, 16-cyl engines. These locomotives were used in regular freight service and averaged one 240-mile round trip per day with loads of from 1000 to 2000 tons.

After 15 months of operation on the O & W Railway, data were derived for comparing wide-cut diesel fuel used in three locomotives with conventional diesel fuel used in the remaining diesel engines. Table 1 gives typical inspections of the test fuels.

First thing revealed was that wide-cut fuel is equivalent to conventional fuel in its effect on engine condition. Inspection of the engines operating on the wide-cut fuel indicated that this fuel compares with the conventional fuel as to deposit-forming tendencies, both fuels forming very moderate deposits. Extent of air-intake port plugging observed with these fuels, shown graphically in Fig. 2, illustrates this.

The deposit level in the intake ports was very low for both fuels. . . . ports 7% plugged for the wide-cut fuel compared with ports 9% plugged with the conventional fuel after 40,000 miles. It should be noted that these diesel engines are so designed that engine performance is not adversely affected until at least 50% of the port area is blocked.

Second test disclosure is that observers could not detect any appreciable smoke when operating these Electro-Motive engines on either of the two fuels.

A static test was run to get an accurate picture of the relative consumption of wide-cut and conventional diesel fuels in railroad equipment. This test was carried out (on one of the locomotives that had operated 11 months on wide-cut fuel) by absorbing the power output of the generator as heat and measuring the power in terms of electrical units.

Note that in contrast with the normal constant speed (with an infinite number of speeds to choose from) and infinitely variable load type of automotive diesel operation, the locomotive operator has a choice of only eight throttle positions. These throttle positions represent equal increments of diesel engine speed, together with pre-established loads (fuel rack settings) for each speed. This produces a nearly straight line power-versus-speed

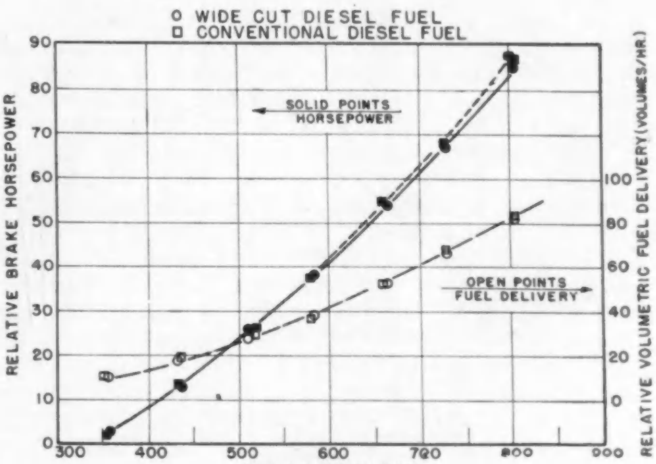


Fig. 3.—Power and consumption of wide-cut and conventional diesel fuels in railroad service

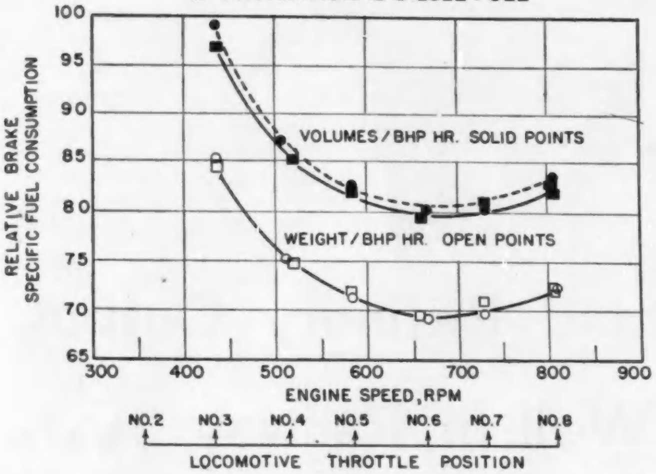


Fig. 4.—Specfic fuel consumption of wide-cut and conventional diesel fuels by both volume and weight

curve and also means that the static test conditions can easily duplicate actual service operating conditions.

This static test indicated that, over the speed and load range, the wide-cut fuel gave about 1% less power than the conventional fuel and that about 2% more of the wide-cut fuel was consumed (on a volumetric basis) per horsepower hour. These differences generally agree with the volumetric net heat contents, which show this particular experimental wide-cut fuel to be 1.4% lower than the conventional fuel in this respect.

Fig. 3 compares the power output obtained at the various throttle positions. Note that somewhat less power was obtained at the higher speeds with the wide-cut fuel. If power differences are averaged on the basis of equal operating time in each throttle position, a 1.1% average power loss is obtained for this particular test fuel.

Volumetric fuel consumption data shown in Fig. 3 indicate that the same quantity of each fuel was injected at any given engine speed. Fig. 4 shows the specific fuel consumption data. Considered on a gravimetric basis, both fuels were alike; the same weight of fuel was required to produce a brake horsepower hour in each case. On a volumetric basis, as shown in Fig. 4, a 1.9% higher consumption was indicated for this wide-cut fuel.

Since the fuel modifications considered for the diesel locomotive might be considered in the automotive and related fields, the wide-cut fuel was compared with a conventional diesel fuel in four automotive-type engines on laboratory dynamometer test stands. These laboratory tests produced more accurate measurement of power output and fuel consumption than was possible in field service tests. They were carried out on a General Motors 71-cu in. engine, a Mack-Lanova 672-cu in. engine, a Leyland 7.4-litre engine, and a Thornycroft 4.0-litre engine.

Fuel economy of the wide-cut fuel was compared with a wide range of diesel fuels, from a kerosene to a relatively heavy diesel fuel in the General Motors engine. As the results in Fig. 5 show, fuel economy was found to be proportional to the net heating value of the fuel. The engine was found to operate at substantially constant thermal efficiency over the range of fuels tested.

The wide-cut fuel behaved normally in this respect. And in all the laboratory engines the difference in fuel economy between wide-cut and conventional fuels was proportional to the difference in net heating value.

A loss of 1 to 3% in power was obtained with the wide-cut fuel in comparison with conventional diesel fuel in the laboratory engines. This loss is due to the lower heating value, and also the lower viscosity, which results in less fuel delivered per pump stroke at a given rack setting on the smaller automotive engines. And wide-cut fuel produced the same or lower smoke densities.

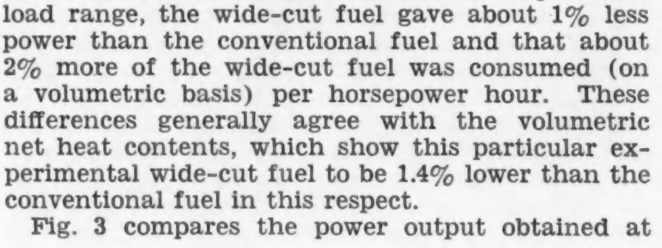


Fig. 5.—Fuel economy of wide-cut diesel fuel compared with other conventional diesel fuels in a General Motors 1-71 engine. These tests were run on a dynamometer at 900 to 1800 rpm, from one-half to full load. Relative fuel economy and heating vale of conventional fuel is 100

Wide-Cut Fuel Safety Aspects

Flash point of a fuel indicates the fire hazard involved in its storage and handling. For this reason most automotive and railroad engine makers have established minimum flash point specifications for fuels to be used in their engines. In the automotive field, use of kerosene-type fuels with flash points of 120 F or lower has firmly established this flash point level as safe. But 150 F flash fuels are normally specified and generally used in diesel locomotives, even though the potential hazard from use of lower flash fuel in railroad service would not seem any more serious than in automotive service.

A survey indicated that federal and state statutes would not prohibit use of 130 F flash point fuels. In fact, two or three railroads were found using 120 F flash fuels. Thus there appears to be no valid objection to its adoption for railroad service.

Instrument Advance Awaits Truck & Bus Industry Help

BASED ON PAPER* BY

Willard H. Farr and George E. Coxon

STEWART-WARNER CORP.

INSTALLATION care coupled with cooperation from makers of commercial vehicles and their components would help make for improved, longer-lasting truck and bus instruments.

Flexible shafts for speedometers and tachometers are a case in point. Routing of the flexible shaft must be carefully planned. Sharp bends shorten core life and increase the load on the driving gears. The shaft manuacturer will supply specifications on minimum permissible radius of bend for any particular shaft size.

A flexible shaft also must be carefully handled in both manufacture and installation to avoid kinking the core. Such a kink causes an annoying waver of the pointer at slow speeds. Almost invariably complaits of unsteady pointer action trace back to manhandling of the flexible shaft by an installer.

Mechanical considerations which determine the practical limit of shaft length are wear, whip, backlash of the core, and wear on the driving gears. We do not recommend use of a flexible shaft over 15 ft long. Even in such lengths both the core and gear sets should be oversize to give best service. Where conditions make a flexible shaft drive impractical because of its length, an electric speedometer or tachometer is preferable.

Drive tips for heavy-duty drives also merit serious consideration. Often a flexible shaft failure stems solely from too-weak a drive tip on the core. Obviously drive tip strength should be correlated to core size used. Our experience shows that a square tip is stronger than a round tip of the same diameter with a swedged tang. We prefer the square type.

Largest drive-tip size now listed in the SAE Standard is 0.187 in. in diameter with a swedged tang. Making this tip 3/16-in. square would provide somewhat more strength. For this reason we recommend that this 3/16-in. square tip and corresponding square hole in the driven gear be considered for listing in the SAE Standard.

Inadequate standardization of drive equipment for tachometers often makes each installation a hand-tailored job. Some engine manufacturers provide a take-off for driving a tachometer, usually on the accessory shaft. Where such a take-off is not furnished, the installer must find other means. This may be an adapter on the distributor shaft, a fitting on the front end of the crankshaft, or a special take-off from the generator.

This lack of standardization often makes tachometer calibration a major problem. Camshaft drives run at half speed of crankshaft drives, and speed of a generator take-off depends on the generator pulley ratio.

Result is that many installations require a gear box or adapter with a suitable gear ratio to bring the speed within desired range. Even then it may be necessary to calibrate tachometer heads individually. Engine makers could help eliminate this confusion by providing a standard take-off on all their engines. Additionally, this would simplify the installation and reduce costs.

This standardization problem carries over to manufacture of speedometer drive equipment, greatly complicated by an endless number of combinations of such items as rear axle ratios and tire sizes. We have done what we can to reduce the number of gear combinations required by using modified tooth shapes in our driven gears to permit operating several driven gears from the same driving gear. Beyond this it is necessary to use other odd or less-used gear ratios. While these gear boxes do their job, they do become an additional component to purchase, install, and service.

Much progress could be made if transmission makers would consult with instrument builders on drive equipment when developing new transmission designs. It often would be possible to standardize on existing gear designs, saving time, expense, and

* Paper "Instrumentation for Trucks and Buses," was presented at SAE Summer Meeting, French Lick, June 10, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

tooling costs of special designs. And it would permit the instrument manufacturer to recommend the proper type of gear equipment for satisfactory operation.

Instrument makers are equally eager to cooperate with makers of vehicles requiring heavy-duty instruments. Advantage of such an arrangement is typified by a magnetic speedometer mechanism adapted for motorcycles. The motorcycle's high speed and relatively short wheelbase subject the speedometer to terrifiic vibration. And rough-road operation, where wheels sometimes leave the ground, rapid acceleration and deceleration further torture the instrument.

Under such service, instruments enjoyed a brief but stormy existence. Pointers fanned out under vibration and eventually broke off. Pivot shafts drilled through bearings, speed cups crystallized and broke, and odometer pinions chewed teeth off the dials.

Incorporating several design changes evolved an instrument able to withstand such conditions. End stone and ring bearings of the speed shaft cup are now made of an extra hard synthetic. The speed cup shaft is oversize, the speed cup itself reinforced, and even the pointer made extra rugged. To give the pointer added stability, the magnet is driven at twice the standard speed (2000 rpm at 60 mph) and hair spring tension is increased in proportion.

In addition, a specially shaped cam is provided on the pivot shaft, on which rests a light damping spring. Friction of this spring prevents rapid pointer fluctuations. Odometer dials are anodized to increase their wear resistance. And the flexible shaft has an oversize core to give required life expectancy.

Speedometers embodying this construction have been giving satisfactory performance on motorcycles for a number of years. While this is a case of severe operating conditions, it does illustrate what can be done toward adapting equipment to special service needs.

Sturdier Instruments Urged by Discussers

Field experience points up the need for longer-lasting heavy-duty instrumentation for trucks and buses, discussers agreed.

J. A. Harvey, Pittsburgh Motor Coach Co., cites several cases of short-lived instruments in buses. In a fleet of 15 buses purchased in 1945, for example, all the electrical speedometers failed between 15,000 and 18,000 miles. All the mechanical speedometers of 19 buses purchased in 1947 had 32-ft cables which failed between 10,000 and 12,000 miles.

The Willett Co. also experiences difficulties with flexible shafts of speedometers and tachometers, reports A. W. Neumann. He says flexible shaft failures stem primarily from such faults as improper length (too long or too short), too many bends, bends that are too sharp, improperly fastened shafts, and inadequate lubrication.

Typical of these shaft failures is the one in Fig. 1. In this installation, notes Neumann, "the shaft is stretched so tightly that it couldn't conceivably have a period of satisfactory operation." The installation in Fig. 2 demonstrates the inaccessibility of an adapter located between the transmission housing and the emergency brake drum assembly.

Ralph Bertsche, Jr., GMC Truck & Coach Division, feels that existing instrument types are adaptations of passenger car designs, with more or less minor changes to increase their service life. "Since these changes cannot exceed basic design parameters," says Bertsche, "the result is by no means a truly heavy-duty instrument." From a safety and cost standpoint, premature failure of commercial vehicle instruments is assuming serious proportions in certain instances.

Fig. 1—In this speedometer shaft installation the flexible shaft is stretched too tightly. It passes over the sharp edge of an angle to which the floor boards are fastened and is clamped so firmly that the outer casing is badly kinked in several places. Result: unnecessary friction and wear

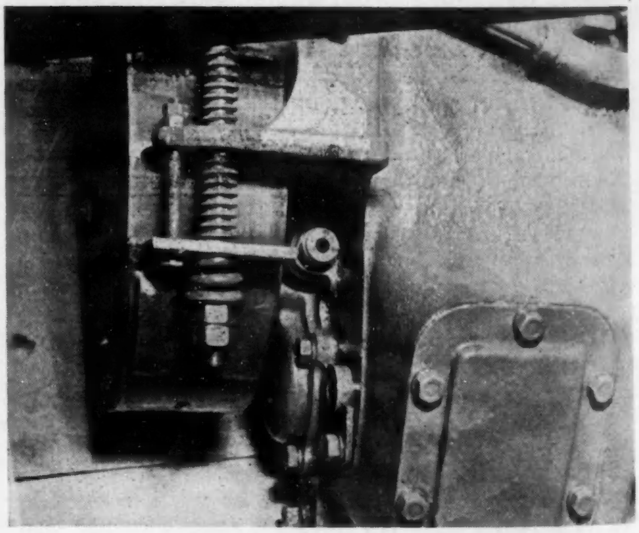


Fig. 2—In this case the flexible shaft adapter is inaccessibly located between transmission housing and emergency brake drum assembly. This small space makes it hard for the mechanic to tighten the shaft properly so that undue wear and loss of lubricant results. And the sharp bend necessary to get around the housing probably would further induce early failure

COMPOUNDING the Piston Engine

BASED ON PAPER* BY

F. J. Wiegand and **M. R. Rowe**

Engineering Manager — Project Engineer

WRIGHT AERONAUTICAL CORP.

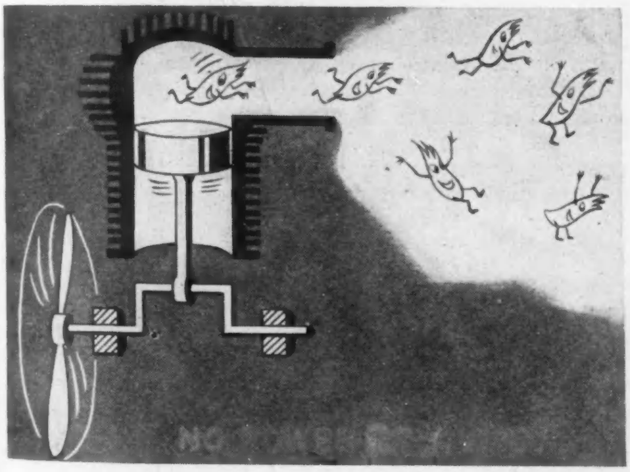


Fig. 1—Exhaust slugs escape to atmosphere when no power recovery system is used

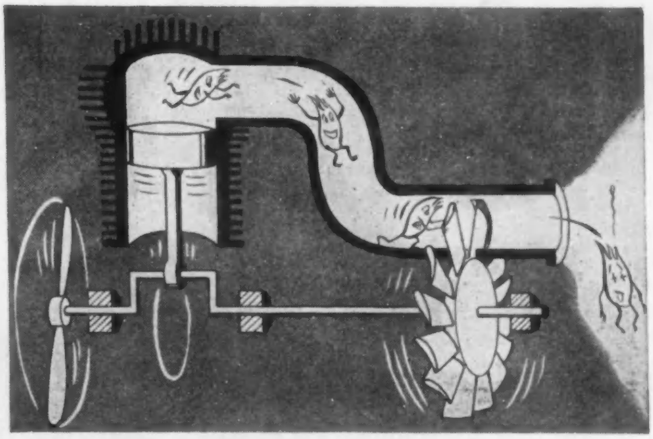


Fig. 2—Exhaust slugs are put to work turning a turbine when blowdown turbines are used to recover power

MAJOR performance gains have been achieved by compounding the 18-cyl Wright Cyclone engine: a 20% increase in power, better fuel economy, and a 5% lower weight/power ratio.

This engine has been compounded by using blowdown turbines to convert the kinetic energy of the exhaust (or blowdown) into useful power, which is then transferred to the engine crankshaft through a system of gears.

* Paper, "Compounding the Piston Engine," was presented at the SAE Summer Meeting, French Lick, Ind., June 6, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

The blowdown system of power recovery was chosen because:

1. It provides a direct increase in engine power and economy over the complete operating range without introducing additional engine development problems.
2. Only kinetic energy in the exhaust is used, so that at some later date further power can be recovered by adding pressure turbines.
3. It can be designed to recover power at a weight increase of only 0.7 lb per hp recovered, whereas the pressure system studied required 1.3 lb per hp.
4. Its installation is simpler than that of other

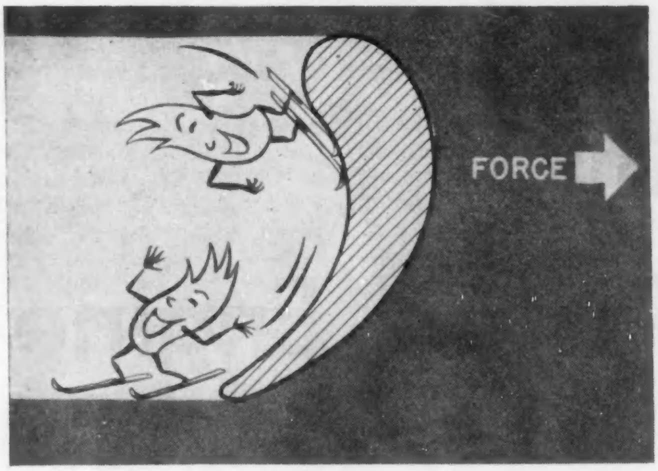


Fig. 3—How exhaust gas flows over turbine blade to produce force on it

compound systems and no pilot attention is required, so that fewer operating problems can be expected.

5. Due to the lack of adverse exhaust back pressure, maximum recovered power is available for take-off, where it is needed most to get the payload into the air.

How Blowdown Recovery Works

Every time a cylinder combustion and work stroke is completed in a conventional engine, a slug of energy is released from the cylinder and escapes to the atmosphere, as depicted by Fig. 1.

These slugs of energy, which are released from the cylinder at a pressure of about 200 psi, come racing down the exhaust pipe at 2200 fps.

Instead of wasting this energy, we can feed it back to the engine by some form of compounding.

There are two general forms of compounding.

In the pressure system, the gas is collected in an exhaust manifold and discharged to the turbine in what is essentially a steady flow.

In the blowdown system, the velocity energy is used directly, without the gas slug being slowed down, and without interference from other energy slugs. Fig. 2 shows how the blowdown turbine captures the exhaust energy slugs and puts them to work in the turbine assembly, which has its output directly coupled into the engine drive shaft.

Since the exhaust gas slugs reach the blowdown turbine wheel individually and separately, without overlapping each other, they create an intermittent torque impulse that accelerates the wheel cyclically and causes torsional vibratory reactions that must be reduced by a damping system.

Fig. 3 shows by means of a cartoon how the gas flows over the turbine blade to produce a force on it. The gas entering the turbine rotor blade from the stator imparts a force on the blade by virtue of its mass and change in velocity while flowing over the blade. This force, the result of the change in momentum of the gas, is combined with the wheel speed to produce the horsepower output that is fed back into the engine crankshaft system.

Design Criteria

The blowdown system of the 18-cyl Turbocyclone has been designed to meet the following criteria:

1. The power recovery turbines are an integral part of the engine. They feed their recovered power directly back to the engine crankshaft system without imposing additional development problems on the basic engine.
2. No additional operating controls are needed.
3. The exhaust gas system of feeding the turbines is an integral part of the engine.
4. The turbines do not impose any additional aircraft installation problems. They do not require cumbersome intercoolers or duct systems, and no in-

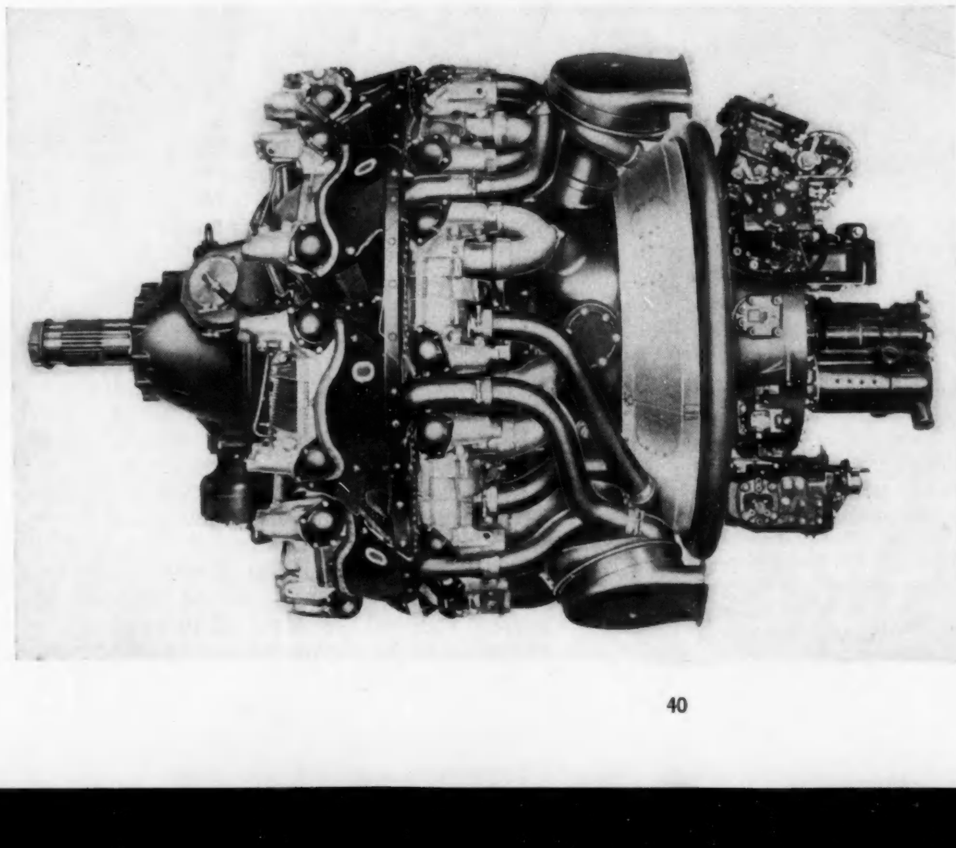


Fig. 4—Left side view of Wright Turbocyclone 18 engine

Fig. 5—Turbine drive system of Wright Turbocyclone 18 engine

crease in the effective engine diameter has been necessary.

The actual design has three turbines mounted on the engine, as indicated by Fig. 4. Each turbine receives the exhaust gas of six cylinders. The turbine wheel torque is transmitted from the turbine shaft (as shown in Fig. 5), through a coupling shaft into a bevel shaft gear located in the engine front superhousing. A mating bevel gear drives a fluid coupling layshaft and its integral impeller. The impeller half of the coupling drives its runner, thereby transmitting the torque to a pinion driving a main crankshaft drive gear located on the engine crankshaft drive system. All three turbines drive into the same crankshaft drive gear. The individual turbine assemblies are attached to the engine by a vee flange clamp, thereby permitting quick removal of the turbine units.

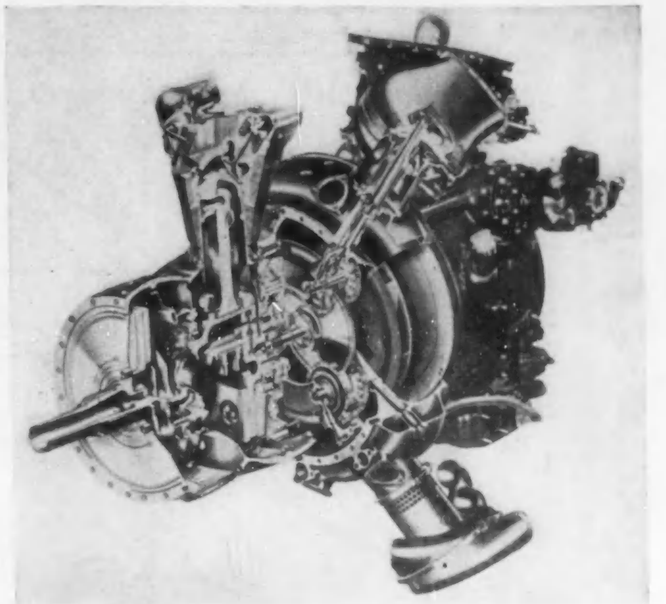


Fig. 6—Power drive system of Wright Turbocyclone 18 engine

Fig. 6 shows how the turbine drive system couples into the engine crankshaft system.

Performance Data

Fig. 7 gives the performance of the engine before and after compounding. Low-speed blower operation was used in obtaining these curves, so that they would show a normal operating schedule through take-off power. Note that the curve of operating specific fuel consumption is shifted not only to the right, but also downward, showing that the actual gain in economy is even greater than what might be expected to result from the extra power provided by the compounding. For example, at 60% of take-off power, a gain in fuel economy of 30% is obtained, although the change in power between the two curves taken on the abscissa scale is shown to be 15%.

Fig. 8 shows the actual per cent gain in engine horsepower and fuel economy over the altitude operating range of the engine. The greater gain in power and economy at high-blower operation is due to the increased air consumption that occurs because of the greater pumping and blower work required.

The mixture strength or operating fuel/air ratio has a considerable effect on both the quantity of power recovered and the fuel economy that can be attained, as shown by Fig. 9. Note that the 22% gain in fuel economy normally obtainable at military power is increased to over 32% when going from an operating fuel/air ratio of 0.10 to one of 0.05.

Future Developments

Although the simple blowdown system was the first method of compounding actually applied to an aircraft engine, because it is the most efficient and the most readily adaptable system so far considered, other types of recovery are being studied. These are,

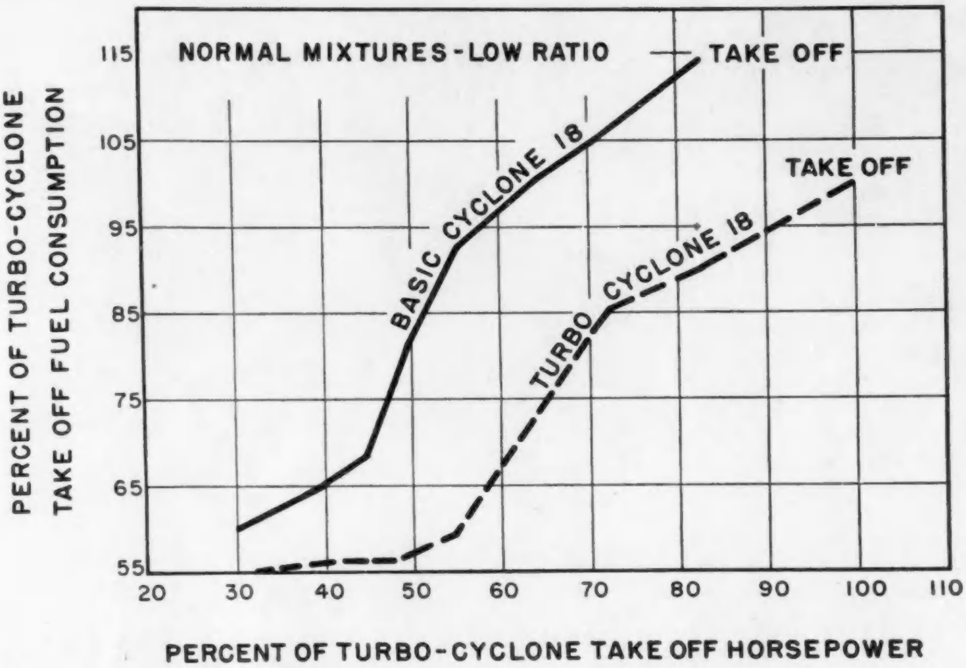


Fig. 7—Performance comparison of engine before and after compounding

in order of their general desirability:

1. The blowdown system of power recovery with an internally located aftercooler, which is considered a logical step from the simple blowdown system to permit increased horsepower for take-off and high-altitude operation at the least increase in powerplant weight. This design will permit an additional increase of 15% in take-off power with no increase in weight per horsepower, as compared with the present blowdown engine.

2. The combination blowdown-pressure system of power recovery, which utilizes an internal engine aftercooler to overcome the effect of exhaust back pressure brought about by pressure compounding. This system will extend sea-level powers to much higher altitudes, but it will increase the engine weight per horsepower ratio. Another possibility is the use of the existing Turbocyclone 18 with an externally located intercooler and turbosupercharger. The weight per horsepower ratio for this combination will be somewhat higher than that of the design just mentioned.

3. The use of increased diameter cylinder bore with any of the aforegoing engines would create basic piston engine development problems, but it is a logical step toward a weight per horsepower decrease of 5-10%, and an economy improvement of 10-15%.

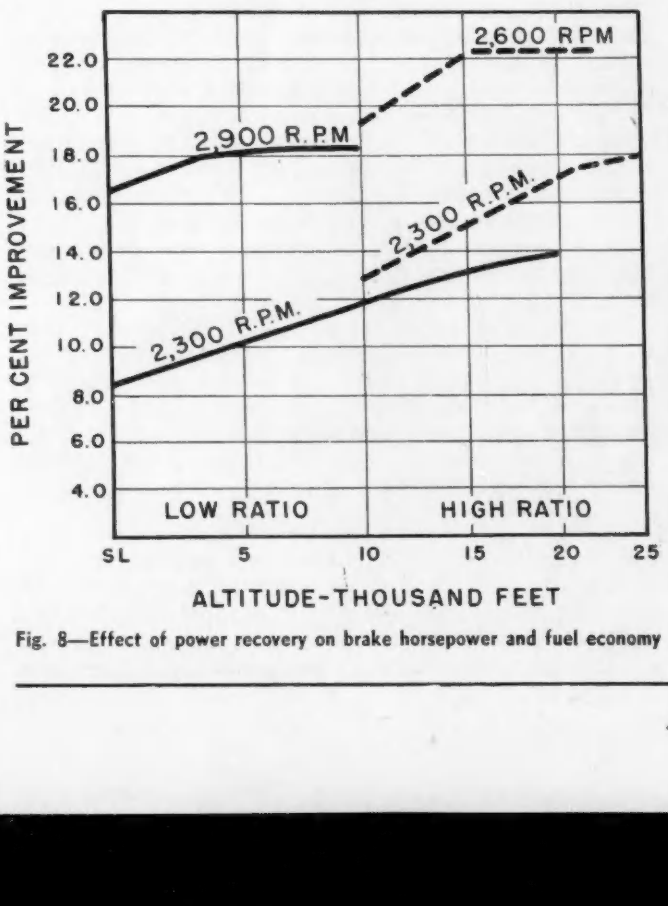


Fig. 8—Effect of power recovery on brake horsepower and fuel economy

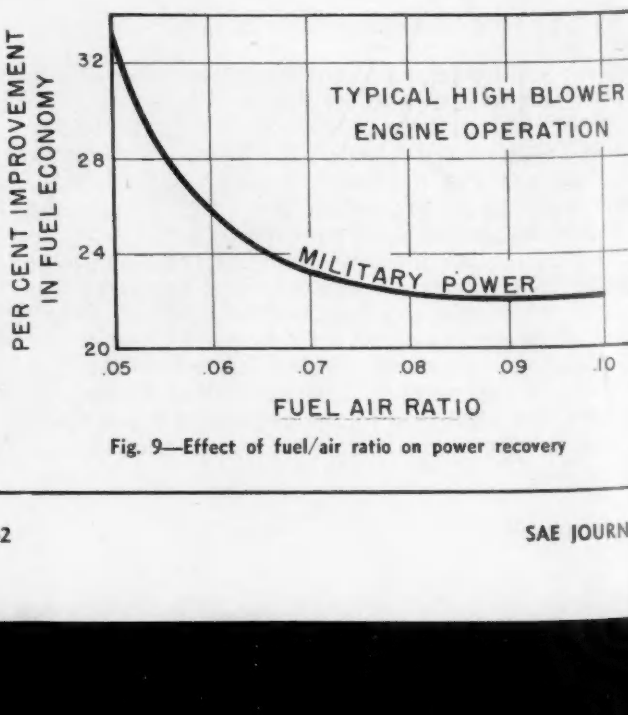


Fig. 9—Effect of fuel/air ratio on power recovery

Some Ideas About Straight Thinking

EXCERPTS FROM PAPER* BY **F. C. Mock** Bendix Products Division, BENDIX AVIATION CORP.

ONE outstanding characteristic of straight thinkers I have known is an active observation coupled with curiosity as to the "how" and "why" of things. This is natural, if we consider that observation is a major stimulus to reasoning.

Observation and straight thought are found to a high degree in young children. Their so-called "bright sayings" are nearly always expressions of simple direct reasoning—and anyone who has been around a four-year-old youngster knows what an all-embracing observation and curiosity they have. In fact, one objective of child training usually is to take this quality out of them, because it makes them uncomfortable to live with. Perhaps we will sometime modify our conception of teaching youngsters in this regard.

Original thought can, of course, be painful; habit is Nature's protection against worry. Most of us can remember how worried we once were as to our ability to deal with the new problems and contact involved in a new job. We can also recollect that, within a few days, the job seemed to become easier; we weren't afraid of it; we could relax and handle the routine. In other words, we had acquired a mental habit. Very few of us could stand it, I think, if we had to go to an entirely new and different job every three days in order to make a living. So actually, habit of thought, the ability to fall back on precedent in dealing with our problems, is one of the merciful things in our life.

But, we should recognize habit of thought for what it is—a palliative or sort of rest. We should be careful not to rely on it more than we have to. Just as hanging from a horizontal bar one minute each day will keep a man from becoming stoop-shouldered, so one daily episode of original thinking will do much to keep us out of a rut.

Another characteristic of successful straight thinkers is confidence in their ability to reason correctly even though contrary to current opinion. This, I suppose, comes partly from experience and partly from reliance upon the universality of Nature's laws. Perhaps the greatest factor in the Wright Brothers success was that after watching gulls with a ratio of wing area to weight which they (the Wright Brothers) could re-produce, glide slowly through the air close beside them, they had an unshakeable conviction that, given an engine as good as that of the 1903 automobile, *men simply had to be able to fly*. So, being absolutely convinced that flight was possible, it was easy for them to continue their long and difficult road of development in spite of public unbelief.

The Process of Invention

The old idea of invention was to look at something nearly everybody else had seen, and get a new "hunch" on it.

Actually, the best formula for invention is to develop a new method of seeing something no one else has yet observed; find out how it acts, then employ common sense to put it to use.

Most of the so-called inventions with which I am familiar, that were major steps forward, were not flashes of genius at all, but instead were inevitable conclusions from new observation plus straight reasoning. Even on smaller problems, when you are at an absolute loss and can't imagine what to do next, go out and experiment with anything that even simulates the action desired. The chief danger of mathematical analysis without experiment is the great chance of ignoring or wrongly appraising major determining factors.

Summarized, my suggestions for stimulating and using original thinking, are:

(a) Cultivate the habit of analyzing problems on the basis of what you know; what you need to know; and how to go about learning what you need to know.

(b) In a new development, follow this sequence: analyze, observe or experiment, re-analyze, again check by experiment, and so on, until both theory and observation correlate.

(c) As a result of the foregoing, you can have full confidence in your conclusions, regardless of current opinion to the contrary; but, be practical!

(d) In new development, check the basic factors first.

(e) Study how your mind works best and easiest; and learn to employ it that way.

* Paper "Original Thinking, Its Stimulation and Use" was presented at SAE Detroit Section Student Activity Meeting, March 28, 1949.

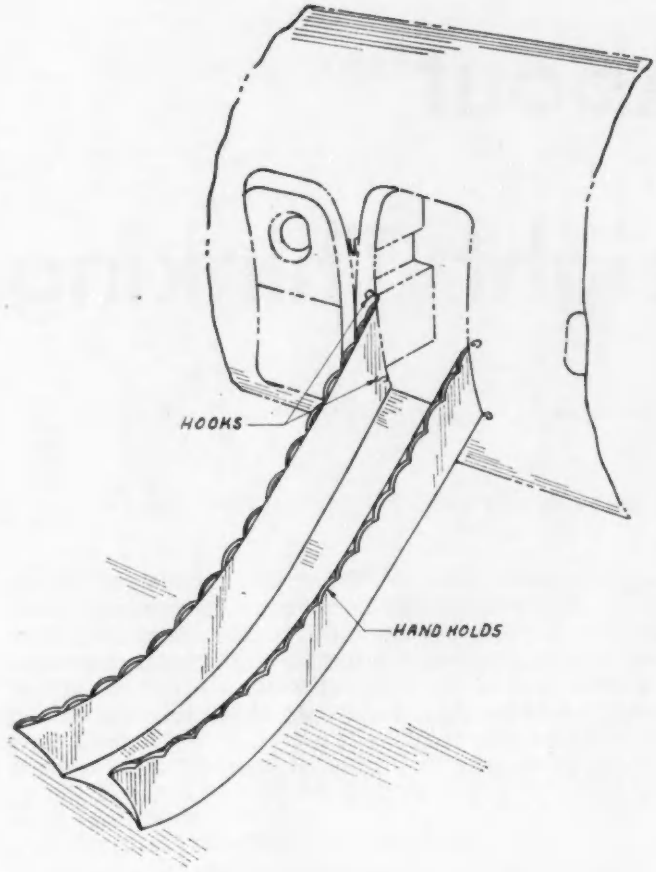


Fig. 1—Emergency evacuation chute

Evacuation

BASED ON PAPER* BY

O. E. Kirchner Director of Engineering
Tulsa Maintenance Depot
American Airlines, Inc.

WHEN a disabled plane makes an emergency landing, lives may depend on the speed with which passengers and crew leave the plane—and they will be able to get out fast only if the plane has been properly designed and equipped for this contingency. Doors and other exits must open easily and quickly. If exits are high off the ground, a safe and fast way to get down to the ground must be readily available. Any other equipment that might aid in the evacuation must be carried.

Doors and Exits

Doors, in addition to their normal operational function, must be designed so that they can be opened from the inside just as soon as the landing has been made. For instance, at least one airlines operator is removing the electrical locking solenoids from the front doors of his Convairs, so that they can be opened even after an electrical failure.

It seems pretty well agreed that all doors and exits should open out, which is in line with present codes for public buildings. If this is done, it is important that the doors be hinged at the front or top, to avoid trouble in case they are inadvertently opened in flight. (The slight opening of the door that might occur at flight speeds with top hinges is not critical.)

Special locking provisions are required, however, when doors open outwardly on pressurized aircraft. For example, notches are applied to the locking pins or plungers on the DC-6 so that if, for some reason, creep occurs in these parts, the door can open slightly until the notches are engaged, allowing slow decompression and loading the plungers, thus stopping any further action of the mechanism to unlock. With the locking bolts in the notched position, the forces on the door or exit are great enough so that manual operation of the door past this point is also impossible. Only after cabin pressure is equalized can the mechanism be operated further.

Operators as a group feel that our present procedures for opening emergency exits are still a little too complicated, that further thought must be given to this problem.

Some operators go so far as to recommend that in future aircraft an ample door to the outside, which can be recognized as such, should be located at the front of each passenger compartment. Maybe this is going a little too far, as it would appear that present emergency exits have not yet been given a fair opportunity to prove themselves.

A definite ratio of extra exit openings to number of passengers has been developed, so that plenty of exit space will be available for emergencies. In the early days of aircraft design, the particular location of these exits was not given much thought. For instance, even the early DC-3 had to have emergency exits along the side of the cabin but, since the cabin was close to the ground, it didn't much matter where the exits were.

As airplanes grew in size, tricycle landing gear was added, and larger powerplants with larger propeller diameters were used, the cabin was put higher and higher off the ground, so that it became necessary to locate the exits very carefully.

Floors of our late-model transports are 9-10 ft above the ground. To locate an exit out the side of a cabin so far above the ground may be anything but safe. A person may be seriously injured while attempting to leave an aircraft this high off the ground, especially under the excitement of an emergency.

The seriousness of this problem was not realized until some of our late models had already emerged from the factory with openings located one bay

* Paper, "Aircraft Evacuation on Land—Equipment, Stowage, and Procedure," was presented at the SAE National Aeronautic Meeting, New York City, April 11, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

# of Aircraft Making Forced Landing

ahead of the leading edge of the wing.

This condition has been corrected on later designs, so that exits from the cabin are now through windows that place the passenger on parts of the structure from which he can then proceed to step down to the ground or out along the wing span away from fire or other damage.

Exit Aids

Although emergency exits can be placed so that passengers can step out on the wing panels, entrance doors cannot be so located; consequently, some method of getting passengers to the ground must be provided for these openings, which also are 10 ft above the ground.

This equipment must be safe for use by a passenger load that probably includes small children and elderly persons. It must be safe for use by persons who are excited and maybe even panicky, especially if the plane is on fire.

Various types of folding and Jacob's ladders have been tried, but they are far from satisfactory.

Far better is the chute, of the general design shown in Fig. 1, which appears to provide a safe and quick method of exit for all passengers, young and old, under the conditions of a forced landing.

This chute is made of vinyl-coated fiberglass, 0.0065 in. thick and weighing about 5.4 oz per sq yd. It is easy to install, and stowage is not a problem. It can be used, no matter what the position of the plane after landing.

It even provides for the possibility of the DC-6 suffering a nose wheel failure, so that the tail is in the air, which puts the loading door about 23 ft above the ground level.

In fact, the development of the evacuation chute was started by installing it on a mockup that included the outline of the DC-6 main cabin door entrance, 23 ft off the ground. Various individuals slid down this chute while it was held by two persons on the ground. Ease of operation and a sense of security were immediately apparent.

A quick method of installation was developed. Rings were located in the door frame and a scheme of colors was utilized to help the crew install the equipment properly. The chute's mounting rings and their respective attachments carry the same color. The chute was designed so that it could be quickly removed from its container, with the hooks exposed so that they could be attached, and the chute would be ready for discharge through the door when the plane came to rest. If the pilot knows ahead of time that he is going to have to make a forced landing, he can notify the stewardess in sufficient time so that the chute can be properly engaged before the landing is made. The position of the door, whether open or closed, does not retard the installation.

Other Equipment

The merits of some of the other equipment carried for emergency landings is still being debated.

For instance, it has not yet been settled whether impact or inertia actuators, designed to go into operation as soon as the plane hits the ground or has a ground collision (horizontal deceleration of $3g$), should be installed to carry out such functions as:

1. Shut off main electrical power.
2. Set off the fire-fighting bottles in the engine nacelles and the related firewall shut-off valves.
3. Turn on emergency lighting supply.
4. Release the chute in preparation for putting it out of the door upon landing.

The best form of emergency lighting has not yet been determined. One operator has installed inertia-operated flashlights. Others provide manually operated ones. We still don't know whether the portable features should be retained so that the lights can be used away from the plane or if an installation wired in the airplane with a separate power source would be acceptable.

Hand axes are practically standard emergency equipment, but not all types are satisfactory. The handle mustn't be too long because it may have to be used in close quarters and it must be of a type that doesn't tend to get stuck in cutting into aircraft structures.

Although the advisability of installing a crash-landing alarm device (such as the Gibson-girl radio used by planes that alight at sea) has been discussed for many years, it now seems to be agreed that any passengers or crew alive could easily create smoke signals, and also as soon as the pilot becomes aware that a forced landing must be made, he can send out emergency signals on his radio.

Some airlines want a public address system, whereby instructions could be announced prior to landing, others doubt its real worth in emergencies. In any case, it couldn't be depended on after contact with the ground had been made, since by then the electrical power would probably have been shut off.

Finally, it is important that all removable parts in an aircraft, such as hand fire extinguishers, be installed so that they stay put during a forced landing.

BODY

EXCERPTS FROM PAPER* BY

James Watt

formerly of Ford Motor Co.

MY remarks are directed to those interested in learning how certain automobile body interior materials are made and used . . . materials such as genuine leather, artificial leather, waste cotton, and woven materials.

Genuine leather comes from what are known as green hides obtained from the various meat packing plants. Steer hides are usually considered more desirable than those of cows or bulls, although many cowhides are tanned for upholstery purposes.

Leather tanning renders the fibers and the gelatinous substance in the green rawhide impervious to putrefaction and decay by the chemical action of the tanning agents. Genuine leather is usually tanned by one of two processes: (a) the vegetable process which employs the tannin extracted from the bark of such trees as oak, hemlock, and sumach, or (b) the chemical process, which utilizes chiefly the salts of metallic chromium and is referred to as chrome tanning. Combinations of both methods (described in the trade as chrome retans) are also used. In such cases, before the hide is fully tanned by the vegetable process, it is placed in a chromium salt solution for the completion of the tanning time. After tanning, hides are split into layers, and these layers are classified as top grain, (or hand buff), machine buff, deep buff—splits and slabs. These terms describe the particular location or position in the hide from which the layer was taken.

The layers nearest the hair cells on the outside of the hide are most desirable because their texture is closer. The very top cutting (described as Top Grain) is the most desirable of all and is consequently the most costly. After hides are split into the different layers, coloring material is applied to the surface. Inside layers, which have little or no hair cells, are subjected to an embossing operation which produces some desired pattern effect. Millions of hides are produced and tanned each year in the United States, and many additional millions are imported from other countries, principally South America. Genuine leather has excellent wearing qualities, but because it presents a less warm appearance than fabric, its principal use has been in convertible and commercial models. Its use in closed models has been limited chiefly to miscellaneous appointments and accesories.

Artificial Leather today falls into two main classes, those coated with pyroxylin, and those coated with one of the vinyl products, usually vinyl chloride and vinyl acetate, both of which have had remarkable acceptance in this field. Rubber coated fabrics, popular a few years ago, have been to a great extent replaced by the newer vinyl products.

Pyroxylin is made from cotton linters which are treated with nitric acid to produce nitrocellulose. This white nitrated cotton is dissolved in a solvent, usually Ethyl Acetate, and, in its liquid state, is mixed with castor oil and color pigment, which when all thoroughly blended together provides us with the colored pyroxylin dope ready for application to the cloth backing.

Vinyl chloride and vinyl acetate are manufactured by rather lengthy and intricate chemical procedures. Such common materials as ordinary salt and acetic acid provide respectively the chloride and the acetate, while the vinyl part of the compound is usually derived from acetylene made from calcium carbide whose parents are such common materials as coke and limestone. These vinyl esters are made in powder form which is dissolved in a solvent and to this liquid is added the necessary oils, plasticizers and color pigment to produce the coating material.

Artificial leather is usually made by spreading one or several coats of these so-called plastic dopes on cotton fabrics of whose constructions is predetermined by their ultimate use. After drying the coated cloth is run through embossing machines which produce the desired patterns. In recent years remarkable results have been obtained by these embossing operations. The resemblance to the natural grain cells, even including the scratches in a hide of genuine leather, would deceive all but the experts. In recent flexing and rubbing tests, the vinyl materials have shown remarkable stability—and, since they have shown equally satisfactory results under extreme heat and cold, there should be no doubt about the expanding uses of these new materials in many fields.

Waste cotton is the material used in the cushion pads which cover the seat and seat-back spring assemblies. It is composed chiefly of three different grades: cotton linters, cotton picker, and cotton fly.

Since a soft strong cushion pad with the proper resiliency is desired, proper percentages of these ingredients should be used. Linters provide the resiliency, while picker and fly provide the strength.

The linters are cut from the cotton seed by machinery. Those produced by the first cutting known as 'first cut linters' are longer and make the best cotton pad.

Picker cotton is obtained during the first cleaning operation and usually contains considerable quantities of extraneous vegetable matter described as motes, shives and leaf. Its quality and grade are determined by the quantities of these impurities present.

Cotton fly, is usually found around the carding,

* Paper "Are We Doing a Good Job of Body Interiors" was presented at SAE Detroit Section on Nov. 15, 1948.

UPHOLSTERY MATERIALS

What they are... and How they are made

spinning and weaving machines and might be described as the drippings from these operations.

There are many grade and classifications of waste cotton and their proper selection and blending requires a broad knowledge of the qualities and characteristics of the different lots. A good blend—and one quite commonly used—requires 60% new linters, 20% new picker cotton and 20% white fly. Considerable quantities of this blended waste cotton are also made into cotton batts of various thicknesses for piping the cushions and cushion backs in pleated designs.

In addition to these cotton materials, many automobile manufacturers specify an inner layer of rubberized hair or rubberized vegetable fiber which adds considerable strength and resiliency to the assembled seat unit. Foam rubber is also used as a part of the cushion pad. Making it is like the beating of egg white by a housewife. Crude latex is beat up in a beater by mechanical means, or is foamed by the forced introduction of gas. To this fluffy mass of foamed latex is added certain chemicals which act as stabilizing and jelling agents, preparing the material for the final molding and curing operations. Although its cost is higher, foam rubber makes a very desirable cushion pad and is beginning to find greater popularity in cars in all price ranges.

Woven Materials, the largest of the groups, break up into fabrics woven from (1) vegetable fibers, (2) from synthetic fibers, and (3) from animal fibers. Vegetable fiber includes principally cotton and jute. Synthetic fiber principally rayon and nylon, and animal fiber principally mohair and wool. Skillful blending and manipulation of these fibers in their many grades and qualities contributes largely to the finish, the feel, the appearance, and, of course, the price of the finished cloth.

We all know that the weaving of cloth consists of the cross-lacing of warp yarns which run lengthwise and filling or weft yarns which run crosswise—and that the diversity of the methods of interweaving these warp and weft yarns gives the almost infinite variety of textile fabrics on the market today.

Cotton, although represented by certain varieties and marketed under such names as Uplands, Lowlands, Peeler, Sea Island and many others, is chiefly valued by the length of its staple. Such terms as middling, good middling, good ordinary, etc., refer not to the staple length, but to the condition of the cotton—its whiteness, the fineness of its staple, the amount of foreign vegetable matter contained. Highest quality cotton is that with the longest staple, the finest texture, clean and of a white color. Some cotton of exceptionally long staple and high quality is still imported from other countries, especially Egypt and is used in the manufacture of fabrics and lace of exceptional fineness—also in the automobile industry for making high grade sewing thread.

Visitors to a cotton mill will probably recall the picker machine, (the first operation) which loosens up the cotton in the bale, and gives it its first cleaning operation; you may remember the carding machine (that very important second operation) which cleans the cotton still further and places the fibers in a more or less of parallel position producing what is known as a card sliver. Operation three, the drawing machine, takes several of the card slivers at one time and draws them through a series of rollers to straighten the fibers still further and creat greater uniformity. The thick fluffy rope of cotton produced here then goes to the roving machine where it is reduced in size and given a slight twist to provide the strength needed for the next and last operation, the spinning machine. There it is finally converted into yarn and woven into cloth.

Hundreds of different cotton fabrics are woven and the different trade names often applied to the same fabric in different localities presents a most perplexing problem. Those used to the greatest extent by the automobile industry are known as grey goods and include such items as sheeting, drill, twills, broken twills and sateens.

Upholstery fabrics made entirely from cotton, especially flat fabrics, have never been received with much enthusiasm by automobile people. Although much cheaper, such fabrics soil readily and are hard to clean; But with continued rising prices, it may be expedient to overlook some objections.

Without question the most revolutionary chapter in the age old textile industry was discovery and manufacture of synthetic fibers from chemicals. The advent of viscose rayon in 1905—when the Viscose Co. produced its first spinning of rayon filament— ushered in an era of development almost without equal in any industry. From a production

of less than 400,000 lb in 1910, the total U. S. rayon yarn production in 1947 went to almost a billion lb. Although four different kinds are usually listed, the bulk of rayon made in this country falls into two groups—viscose rayon and acetate rayon. Cotton or wood pulp are usually the sources of the basic cellulose required for both types.

The mechanical operations for producing both viscose and acetate rayons are much the same, the chief difference being the type of solvent used to liquify the cellulose pulp and the chemical solution used to set or harden the filament as it is squeezed through the small holes in the spinnerette. Each hole in the spinnerette forms a filament three times finer than human hair, and a group of these filaments are twisted together to make rayon thread. Some rayon is used as yarn in automobile fabrics and for decorative effects in trimming accessories, but it is also used to a great extent in the form of cut staple rayon as a substitute for wool in woolen fabrics. Because of their different individual reactions to certain dyestuffs, acetate and viscose rayons are often used in piece dyed fabrics to obtain varied color effects.

Nylon, the second synthetic fiber, has had even more of a spectacular growth than rayon. Introduced by the Dupont Company in 1938, it was immediately acclaimed as the wonder fiber and is today being experimented with in probably more departments of textile manufacturing than any other material. Nylon is produced indirectly from intermediate chemicals made from such common material as coal, air, and water. Through the magic of chemistry these intermediate chemical solutions are treated under suitable conditions, producing a ribbon of nylon which is allowed to harden then chopped up into flakes and again liquefied and squeezed through the small holes in a spinnerette to form the filaments similar to rayon. Nylon has great strength as well as elasticity and brightness and its resistance to mildew and mold as well as other destructive factors gives it great promise of being one of the outstanding materials to be reckoned with in the fabrics of the future. In addition to rayons and nylons, many varieties of synthetics have been produced such as soyabean fibers from soyabeans, lanital from milk casein, vinyls from acetylene, zein from corn, aralac from casein, saran from petroleum and salt, and a host of others. To this partial list, we might add Spun Glass, produced by forcing molten glass through small openings to form filaments.

Mohair and wool are the final group in our series. Mohair, as you know, is the name given to the fleece of Angora goats which in the United States are raised chiefly in the State of Texas. Like the wool of sheep, Mohair has many market grades. Its quality is based chiefly on the fineness of its fibers, the length of the staple and the degree of luster. The fleece of young goats known as kid mohair is finer than that of the mature animal and commands higher prices. Because of its lack of twist or crimp, mohair is often blended with wool.

Weaving mohair pile fabircs used in automobiles employs not only special machinery, but also a principle of weaving altogether different from flat woven cloths. The pile, consisting of the upright mohair fiber, is produced by weaving two pieces of fabric at the same time. This makes a fabric in the loom with two backs with the pile between, just like a sandwich. As the double cloth comes to the end of the loom, it is cut into two pieces—a top piece and a bottom piece—by a slitting knife which travels back and forth across the machine.

The fact that Viscose rayon and Acetate rayon absorb the same coloring dyes in different ways and produce different color effects provides the pile fabric manufacturer with means of creating a great variety of patterns and colors by blending these rayons with the mohair. Although some automobile manufacturers at the moment seem to be turning away from pile fabrics, their record from a wearing standpoint compared with other fabrics has been extremely satisfactory. Woolen cloth today comprises the largest precentage of all upholstery materials used and with its companion product, worsted, represents one of the oldest crafts in history.

In the United States today, some 45,000,000 sheep provide us with about 360,000,000 pounds of wool each year, but even this big quantity is not enough to satisfy our needs and we are obliged to import, chiefly from Australia and New Zealand, about 25% of our requirements.

The chief difference between woolens and worsteds lies in the method of preparing the yarn to be used in the finished fabric.

Worsted yarns are made from wool of long fibers which is carded, combed, drawn and spun. These operations comb out all the short fibers, called noils, and draw the long fibers which are left into as parallel and straight a position as possible. This makes it possible to produce much cleaner, finer, and stronger yarn than by the woolen system.
woolen fabrics. Woolen yarn is seldom spun finer and spun. Elimination of the combing and drawing operations leaves the short staple fibers in the yarn, producing more or less of a curly unparallel thread, suitable only for the rougher and usually heavier woolen fabrics. Woolen yarn is seldom spun finer than 16,000 yd per lb, whereas worsted yarn could be spun as fine as 50,000 yd per lb.

There is a great variety of woven fabrics, but most of those with which we are concerned fall into three classes—square weaves, twill weaves, and satin weaves. Variations in weave are almost without limit, but all of them are combinations of or are derived from these three basic principles.

Qualities are determined by the weight per yard, the number of yarns crossing each other in a square inch, the fastness of color, the tensile strength, and of course, the finish and fineness of the texture of the fabric itself. That you get what you pay for, can most truly be said about textiles made from wool, as they lend themselves readily to adulterations, through the manipulation of inferior wools and the use of shoddy made from clippings of woolen cloth.

It would be hard to predict what automobile trimming may be made from a few years from now or what it may look like.

There will undoubtedly be greater use of synthetic materials and in all probability, the number of these will be increased, providing both the stylist and the engineer with still more variety of things to be used in auto body interiors.

FIND OCTANE NEEDS of Cars on the Road

A 265-car survey revealed little difference between the octane requirements of the 200 postwar and 65 prewar cars tested. This and other facts are disclosed in the CRC report "Octane Number Requirement Survey—1948," prepared by the Parking Lot Survey Panel, of the CFR-MFD Equipment Survey Group.

Obtained by the Research Technique for Determination of Octane Number Requirements of Vehicles on the Road (CRC Designation E-1-748), these survey data are considered more indicative of the trend in postwar cars than a cross-section of all cars presently in use. Reason: 200 of the 265 cars included in the survey were postwar cars. But the report notes that the small difference between the full-throttle requirement for all 265 cars and the

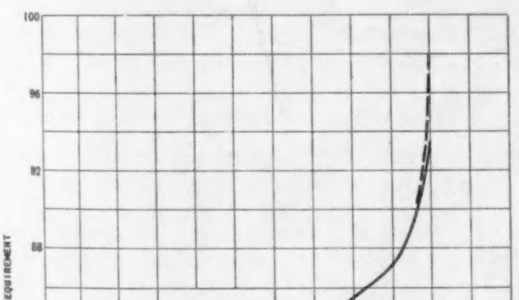


Fig. 1—Distribution of maximum full-throttle requirements of the 200 postwar cars compared with that of all of the 265 cars tested in the 1948 CRC survey

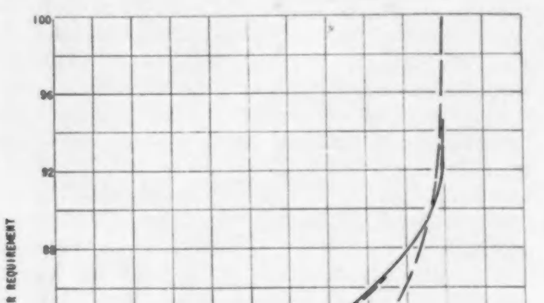


Fig. 2—Shown here are the maximum octane requirements of the 265 cars tested in the 1948 CRC survey as well as those of 473 other cars tested in prior individual surveys

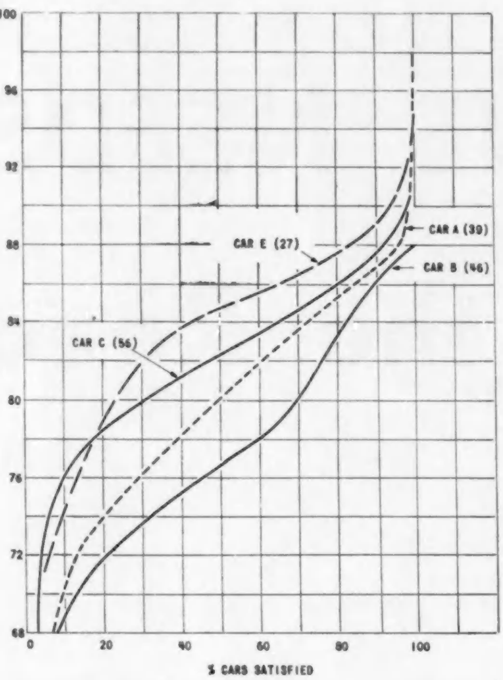


Fig. 3—Distribution of maximum octane requirements by individual car makes. Number of cars of each make surveyed is shown in parentheses

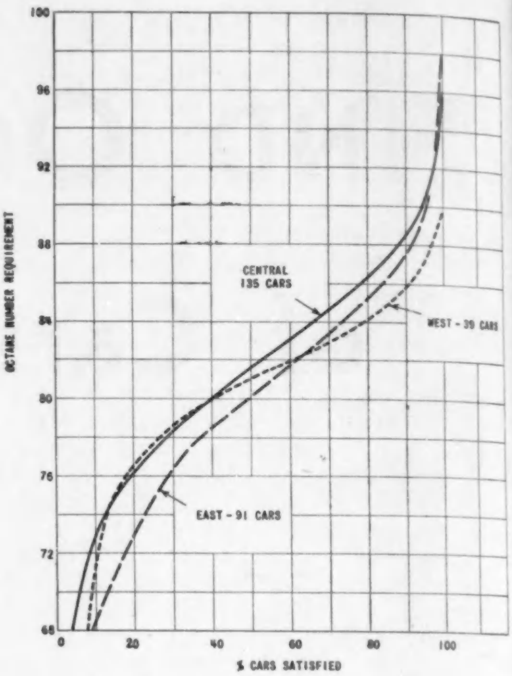


Fig. 4—Distribution of maximum octane requirements by geographical areas for all of the 265 cars in the survey

corresponding curve for the 200 postwar cars, shown in Fig. 1, shows no marked difference in octane requirement level between prewar and postwar cars.

The 265-car curve in Fig. 1 comes from Fig. 2, which shows maximum octane number requirements, in terms of primary reference fuels and independent of car speed, plotted against the percentage of the 265 survey cars with requirements no higher than the octane number levels indicated.

Curve A is based on requirements under full-throttle accelerating conditions. Part-throttle requirements were higher than full throttle for 24 of the 265 cars. Curve B represents peak requirements independent of throttle setting. Too small a percentage of cars were affected by throttle position to make any appreciable difference between the two curves.

Survey Differences Explained

Fig. 2 also includes Curve C, based on data from individual postwar surveys conducted prior to the present CRC survey by test procedures differing from the current test technique. Says the report, higher requirements from the present survey probably stem in part from the fact that the technique was aimed at minimizing changes in engine condition during testing. It further notes that unpublished surveys, which show good agreement at the "50% satisfied" level, seem to support the CRC data.

Sufficient data on four makes of cars permitted construction of individual octane number requirement distribution curves, shown in Fig. 3. While these curves are somewhat irregular due to the relatively small size of each sample, requirement level differences appear to be significant.

In addition to the division among car makes, the report analyzes the data by geographical location. See Fig. 4. The spread in the three curves is fairly small. But the Central or Midwestern area curve position compared to the Eastern and Western curves is contrary to generally accepted ideas.

Knock-Speed Relationship

Another item covered in the report, engine speeds at which maximum requirement occurred, is summarized in Fig. 5. This shows knock to be most prevalent in the low-speed range with primary reference fuels; however this varied widely among the various car makes as well as within any one make. Report observation here is that use of more sensitive fuels, such as commercial fuels, possibly may affect the knock-speed relationship.

Survey data on octane requirements over the speed range are summarized in Fig. 6. In this case the highest requirement for each vehicle was used, whether at full or part throttle. While the curves in Fig. 6 are quite regular, plots for individual car makes show some irregularity because of the comparatively few vehicles involved. But distinct differences are apparent among the various car makes, both as to the general requirement level and spread between the curves.

To determine the percentage of the cars which were knocking on the fuel being used by the owner, full-throttle accelerations were made with each of the cars. Here is what the report tells about this phase of the survey: 120 of the 265 cars, or 45%,

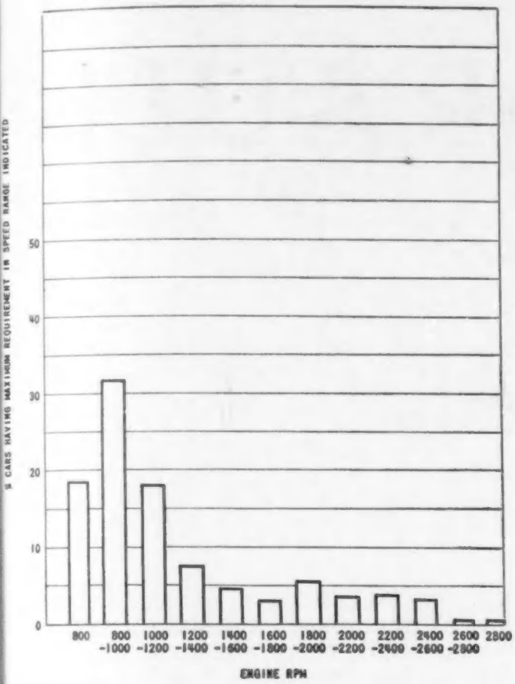


Fig. 5—Speed for maximum octane requirement at full throttle for all of the 265 cars

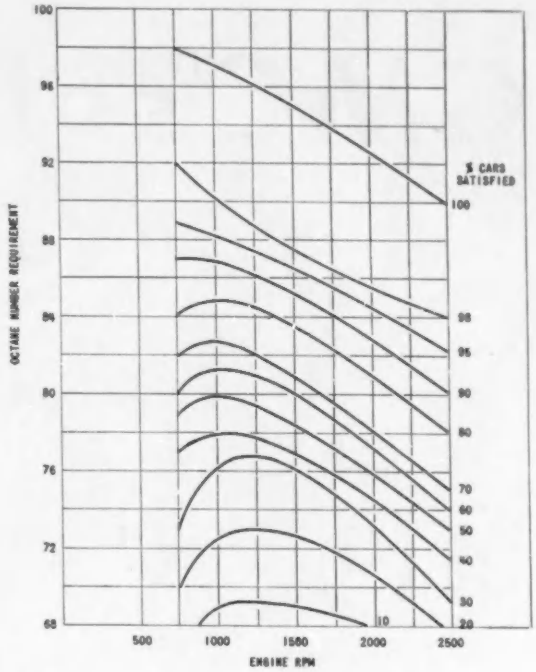


Fig. 6—Distribution of maximum requirements over the speed range for the 265 cars

knocked over a part of the speed range on their tank fuels. There was a wide variation among the car makes tested in sufficient number for individual analysis. For example, 70% of the cars of one make knocked as compared to only 30% of another make.

Data from the various regions, shown in the report, also makes for an interesting comparison. A much larger percentage of cars from the Central region knocked on tank fuel, when run by the CRC technique, than was the case in the Eastern or Western regions. The percentages are: Central, 61%; Eastern, 34%; and Western, 18%.

Fig. 7, prepared from laboratory ratings obtained on the tank fuels, illustrates the extent of variation in fuel quality. Research and Motor Method octane numbers are plotted against the percentage of fuels having ratings below the values indicated. Plots are shown for the total number of fuels together with similar plots for the Eastern and Central regions. Too few fuels were listed for the Western region to warrant their inclusion.

The relatively high antiknock level quality in the East as compared to the Middle West is quite apparent. But the report cautions that this sampling is not necessarily a true cross-section of the fuels marketed in these areas.

Truck Tests Inconclusive

Although 22 trucks also were tested in this program, the truck survey analysis does not present an accurate picture. But the data do indicate a range of 40 octane units between trucks of different makes and as much as 15 octane numbers between trucks of the same make.

This report, CRC-236, has 58 pp of text, including 11 full-page tables and 17 charts, and is $8\frac{1}{2} \times 11$ in. Price: $2.00 to members, $4.00 to nonmembers. It is available from the SAE Special Publications Department, 29 West 39 Street, New York 18, N. Y.

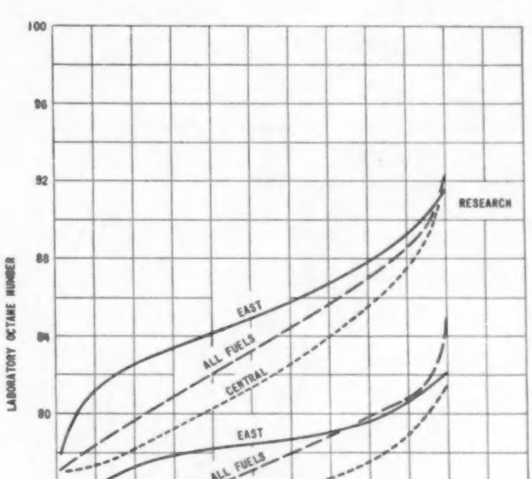


Fig. 7—Comparison of laboratory ratings of fuels found in tanks of the East and Central region survey cars

GMC's HYDRAULIC

BASED ON PAPER* BY

Hans O. Schjolin

GMC Truck & Coach Division

(This paper will be printed in full in SAE Quarterly Transactions.)

THE new General Motors "V" hydraulic transmission offers these six advantages:

1. Nearly 100% accessibility of major working parts while the transmission is in the bus,
2. Excellent performance,
3. A single fluid system which requires no torque converter seals,
4. Reduced weight—about 300 lb,
5. Easy subassembly replacement, and
6. Low operating cost.

The transmission is fully automatic. Torque converter speed ratio changes automatically as bus speed increases; direct drive goes in and out at predetermined speeds. The recommended shift speed is 24 mph.

The driver can get maximum acceleration—for passing a vehicle or climbing a hill—with the bus in direct drive. A special overruling device is provided as optional equipment.

Normal accelerator travel opens the throttle fully and the transmission governor controls direct drive engagement during this travel. When more acceleration is desired, the driver simply depresses the accelerator pedal further, which automatically provides hydraulic drive.

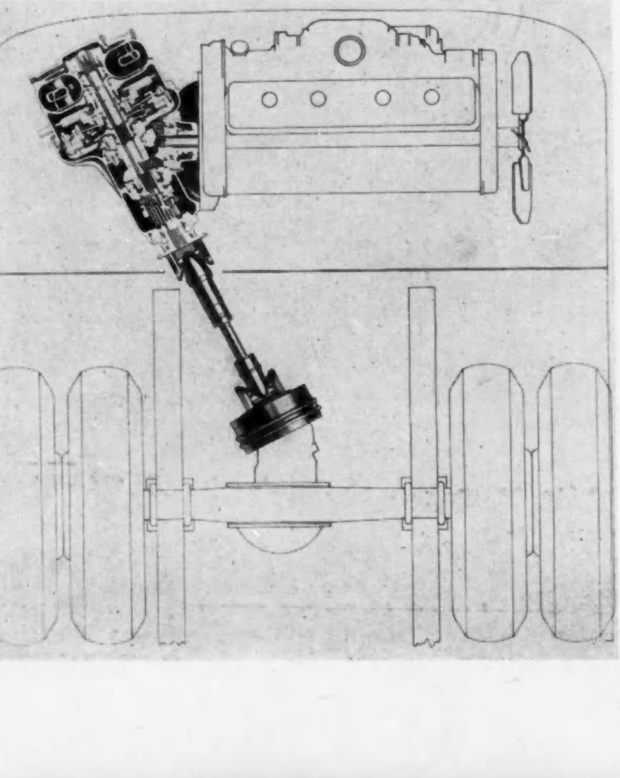
Neutral for parking and forward and reverse for operating the vehicle are obtained by positioning the control lever, located on the instrument board to the right of the steering wheel.

Following is a description of the "V" Drive.

Fig. 1 shows the arrangement of drive units with the engine mounted transversely. Power is transmitted from the engine through bevel gears to an axis in line with the propeller shaft. The drive units are grouped along this axis.

The transmission assembly, shown in Fig. 2, includes all the functional parts. There are no external pump, filters, or tanks.

1



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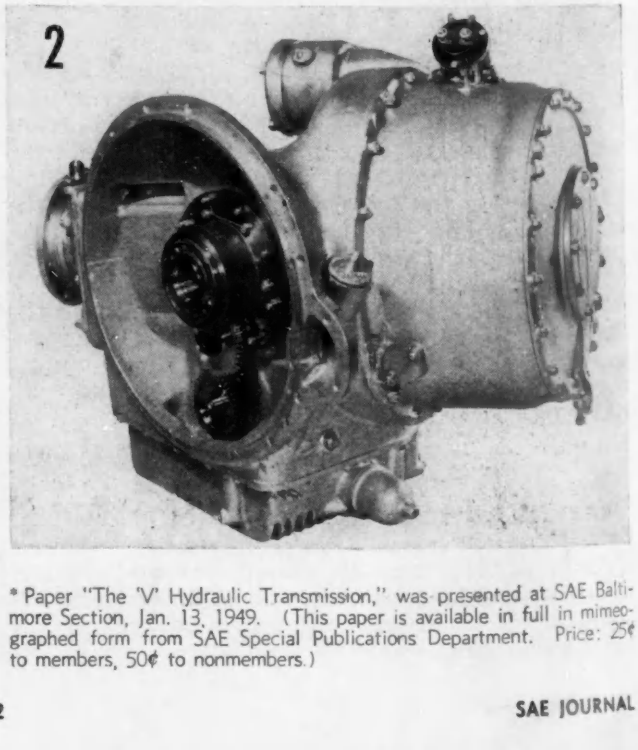
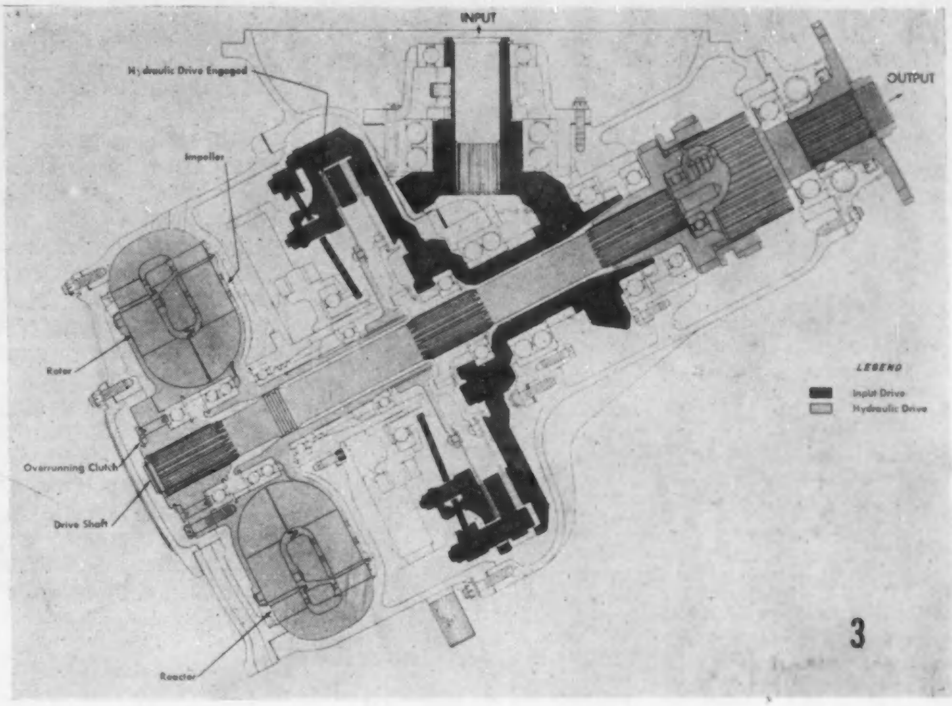
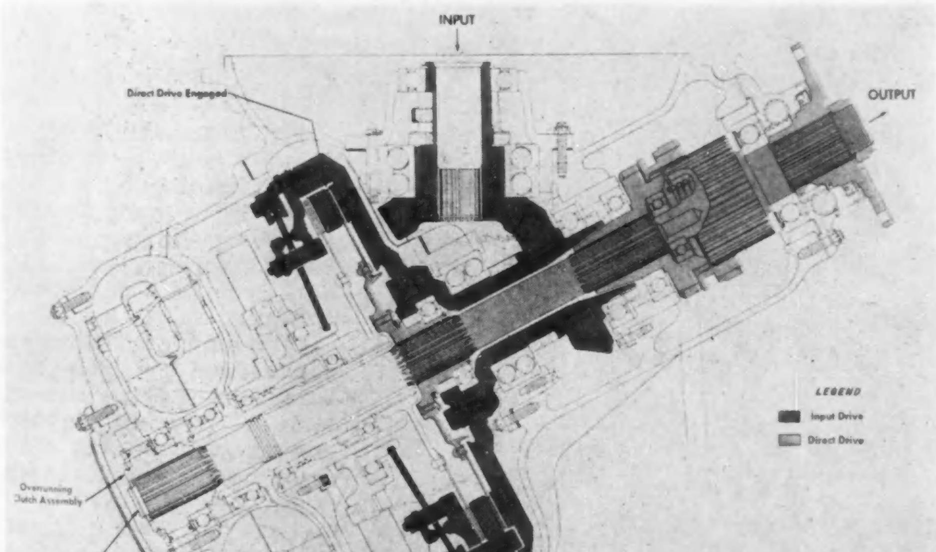


* Paper "The 'V' Hydraulic Transmission," was presented at SAE Baltimore Section, Jan. 13, 1949. (This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

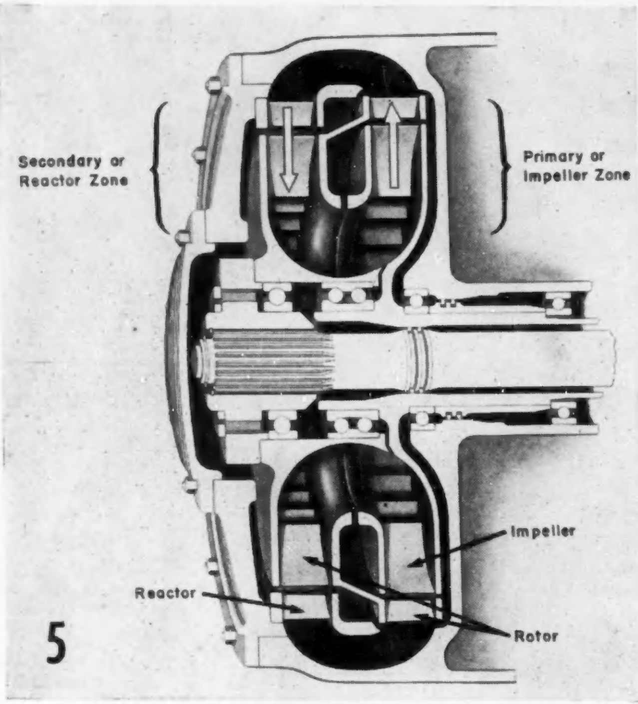
"V" DRIVE

Power flow in the hydraulic drive is shown in Fig. 3. The dark colored elements —bevel gears and clutch— are driven by the engine. Hydraulic drive is engaged in the clutch, and power flows into the converter where speed is reduced and torque multiplied. Drive is transferred through an overrunning clutch into the drive shaft, which is locked to the output flange. Power flow in reverse is the same as for hydraulic drive, except that the reverse gears are engaged, which reverses output flange rotation.





Power flow in direct drive is shown in Fig. 4. The dark bevel gears and clutch continue to be driven by the engine. The clutch, which now has shifted into direct, engages the direct drive member; and power is transmitted into the drive shaft which is located to the output flange. The end of the drive shaft projecting into the converter transmits no power, but merely spins in the overrunning clutch.



The radial power converter, Fig. 5, is attached to the rear of the transmission. It is a light-weight, self-contained assembly which is easily removed as a complete unit. The drive does not pass through this unit as in all other converters. Both the power input and power output are on the same side, with the opposite side closed.

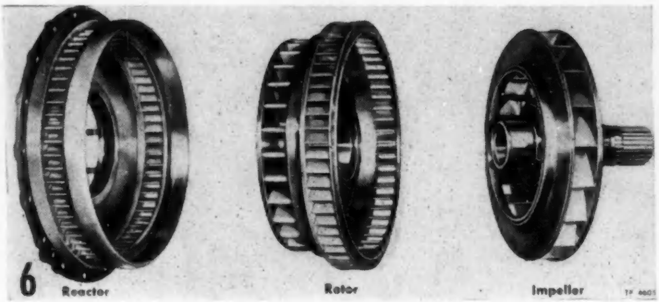
The engine-driven impeller is rigidly mounted in the aluminum casing. The impeller in turn supports the rotor, overrunning clutch, and output shaft. This construction assures excellent alignment and concentricity.

This converter does not require its own fluid. The same oil that lubricates the gears and clutch also transmits the drive through the converter. For this reason no torque converter seals are needed. Oil passes the piston rings to lubricate the bearings and clutch.

Converter working space consists of two parallel zones containing the aluminum blading. The primary or impeller zone contains impeller and primary turbine ring. The secondary or reactor zone contains reactor and secondary turbine ring. These zones are bridged by continuous passages, smooth and free from any blading.

All energy transfer takes place when the fluid is moving radially outward and radially inward in two parallel, radial zones. The smooth, blade-free sections at the inner and outer extremes of the torus guide the fluid from one working zone to another. This construction results in low losses from fluid friction, turbulence, and shock. The net result is a strikingly simple and highly efficient hydraulic power converter.

Fig. 6 shows the three converter elements—impeller, rotor, and reactor assembly (part of the back cover.)



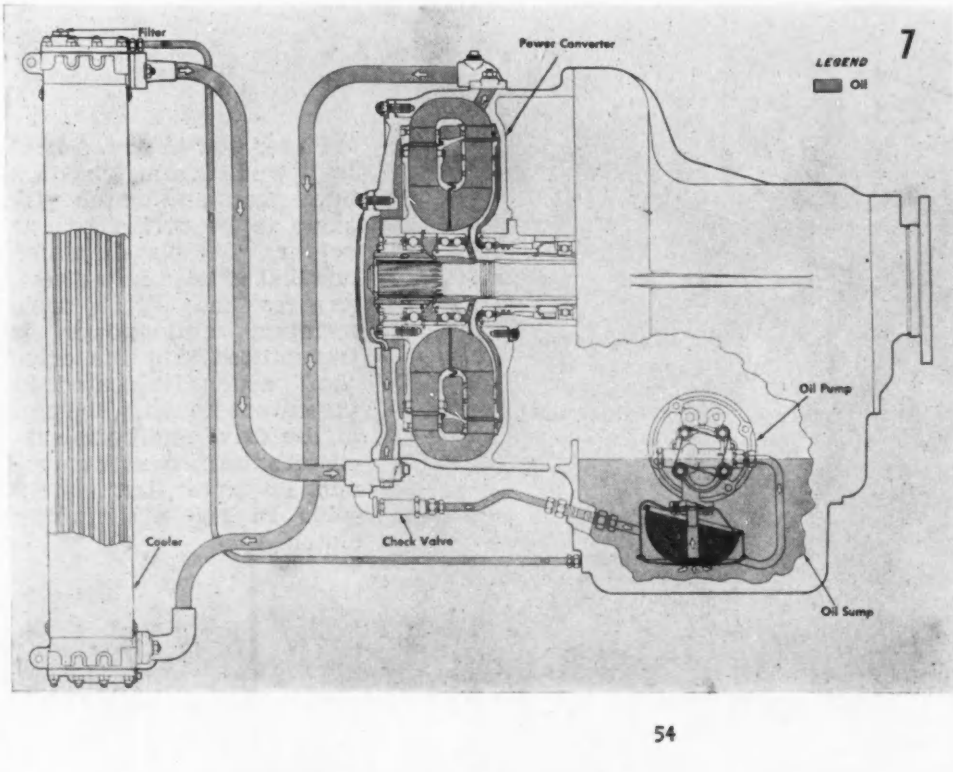


Fig. 7 shows the fluid system. The oil supply, contained in the sump, is circulated by a multiple gear pump in the sump. The same oil draws, lubricates, and cools the entire mechanism.

Oil is circulated through a cooler from the high-pressure side of the converter and is returned to the low-pressure side. A small amount is bled from the top of the cooler to the sump and carries off air or gas which may have formed.

Oil is retained in the converter by simple piston rings. Leakage past these rings lubricates bearing and clutch.

As shown in Fig. 8, the lubrication pump picks up oil from the sump and feeds it to the bevel gears and also to a vertical hole drilled in the casing. This hole registers with three others through which oil is fed to the various bearings, gears, and reverse mechanism.

A hole in the drive shaft provides effective lubrication for center bearings and forward and reverse mechanism. A valve in this shaft prevents passage of oil when the engine is shut off. Oil returns by gravity to the sump. All rotating parts are shown above the oil level, eliminating all churning—a very important feature.

A very light fluid is desirable for good torque converter performance. This oil must also serve for lubrication of highly loaded parts such as overrunning clutch and angle drive gears, for which EP lubricants often are advocated.

Overrunning clutch lubrication was solved by submerging the unit and flowing the oil from the cooler past it. This prevents any accumulation of dirt, and surface heat is washed away as fast as it is generated.

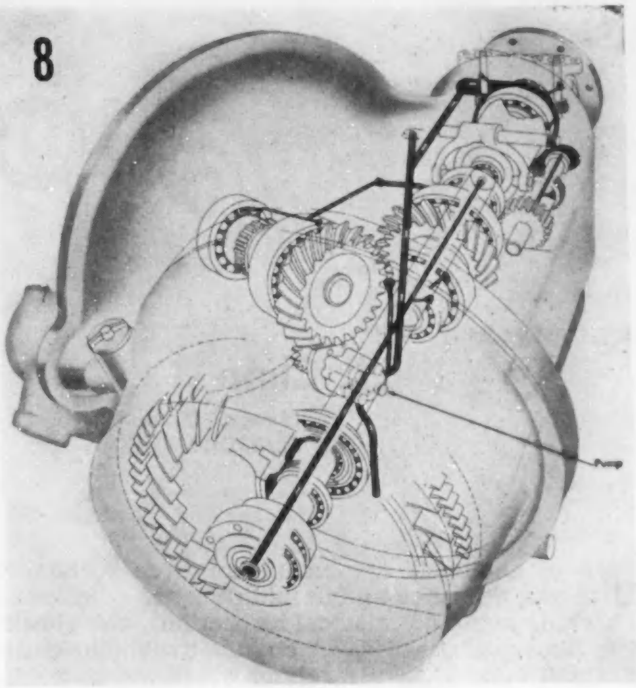

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Fig. 9 shows the unconventional solution for lubrication of the angle drive gears. Past practice has been either to dip the gears in oil or to feed the oil into the entering side of the gears, assuring the proverbial oil film. As the illustration shows, we do just the opposite.

We prevent excess oil from reaching the teeth at the entering side. Instead, the oil is fed onto the teeth as they are coming out of mesh. This washes away the heat of friction while it is still at the surface. Centrifugal force throws the oil off and the meshing teeth are clean and free from dirt. The tooth friction is reduced and the gears actually run cooler with this lubrication method.

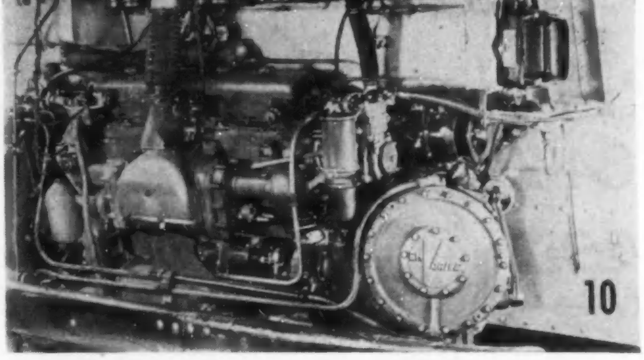
9

Fig. 10 illustrates the accessibility of various units of the "V" Drive while the transmission is on the coach—one of its outstanding features.

By removing one engine support, the assembly is as accessible as though mounted on a work bench. Mechanics can reach every part of the Drive from this comfortable working position.

To reach the overrunning clutch, you remove the cap from the rear of the transmission. The clutch is immediately in view. It is a self-contained assembly which can be easily removed and replaced as a unit.

The clutch is readily inspected by removing the converter, which exposes the clutch to full view. It also can be removed and replaced as a unit. With sump pan removed, the inside of the transmission is exposed for inspection of fluid pump, bevel gears, and reverse gears.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HOW CHASSIS
FOUR-WAY

EXCERPTS FROM PAPER* BY

E.L. Cline

Manager, Dynamometer Division,
CLAYTON MFG. CO

USE of a chassis dynamometer yields economies in four phases of vehicle maintenance—diagnosis, checking repairs, periodical inspections, and checking final adjustments. A chassis dynamometer is nothing more than a machine which simulates all important road grade conditions and continuously shows the vehicle's ability to perform on the road. Without a chassis dynamometer it is necessary to establish an outdoor test course or courses which include all the necessary level stretches, grade of varying steepness, and so forth. With the chassis dynamometer, the type of test course can be instantly selected by the operator, and within the safe, warm confines of the service floor.

Without the chassis dynamometer, vehicle performance is obtained on the road by guess—noting the time to accelerate between two land marks, or topping a hill 12 miles south of the shop. On the chassis dynamometer, the speedometer shows equivalent road miles per hour. Its performance meter continuously indicates vehicle output either in road horsepower, torque, rim pull, or an arbitrary value depending on make or model of machine.

Due to hazards, inconvenience, cost, and questionable results, many fleet men have understandably minimized their road testing. Consciously or unconsciously they balance questionable end results against the cost of putting the vehicle through the road-testing wringer. As a substitute, driver complaints received greater attention. Closer adherence to adjustment specifications are an aid. Accumulation of parts life expectancy records is accelerated.

But there is something fundamental about testing and checking a complicated machine under conditions of its normal operations. Will it generate its horsepower throughout its next trip with minimum consumption of fuel, parts, and man hours? Most mechanics, at some time or other, have said to themselves, "I wish I could get beside this engine or under this rear axle. Better still, I'd like to scramble all over the vehicle to feel it, hear it, adjust it, to attach my instruments to it . . . all while it is being driven on the road."

This and more is the flexibility offered by a chassis dynamometer. It overcomes the many disadvantages of road testing, but retains all the advantages.

The dynamometer quickly and economically lets the vehicle speak for itself while at its normal work. There is no better diagnosis than letting a patient speak to the specialist of his ills, particularly when his parts can be scrutinized quickly or at length if need be, while working under their severest operating conditions.

Simply stated, the chassis dynamometer's job is to test all functions of the engine, transmission, drive line, live axles, rear wheels, and rear tires exactly as they operate on the road, within the space

* Paper "The Organized Use of the Dynamometer to Control Maintenance Expense and Improved Operating Economy," was presented to the following SAE groups: SAE Spokane-Intermountain Section, Spokane, April 5, 1949; SAE British-Columbia Group, Vancouver, April 7, 1949; SAE Northwest Section, Seattle, April 8, 1949; SAE Oregon Section, Portland, April 11, 1949; SAE So. Calif. Section, Sacramento, April 15, 1949; and SAE No. Calif. Section, Fresno, May 2, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

PERCENTAGE OF OPERATORS	USING DYNAMOMETERS FOR DIAGNOSING	VEHICLE ASSEMBLIES
92%		Engine
69%		Engine Accessories
84½%		Engine foreign noises
84%		Transmission—(Conventional and Automatic)
84½%		Drive Lines
69½%		Live Axles

Fig. 1—Summary of answers by dynamometer fleet users to a recent questionnaire reporting on diagnosis of vehicle assemblies

DYNAMOMETER NETS MAINTENANCE SAVINGS

of one working stall; and to indicate performance and to show that final adjustments are being made just right, too much, or too little.

Considering the machine in this simple light—as an improved road test—has allowed more intelligent planning by the supervisor. He can put it to work to yield these four "musts" of economical maintenance:

1. Exacting diagnosis,
2. Thorough after-repair checking,
3. Frequent and adequate periodical inspection, and
4. Correct final adjustments.

A Diagnostician

Before a repair can be made, it is necessary to find out what needs repairing. Driver complaints are often in error or are too general to help locate the cause of trouble. The old familiar "no power" gripe, shouted over the driver's shoulder as he runs out of the yard, tells nothing but that something *may* be wrong.

Some one in Maintenance must take over to determine if the complaint is legitimate and, if so, what must be done. How is the job order to be written? Perhaps no repair is required. Comparison of performance against established "par" for this vehicle will show in a matter of minutes if the complaint is well founded. If required, a complete diagnosis can be done in 20 to 30 min, including the pinpointing of the exact trouble. A correct shop order then can be written. Only the necessary labor and replacement parts need be used in making the repair.

It is well to realize how much wasted labor and parts are consumed in following an incorrect shop order resulting from "shot-gun" diagnosis. Until exacting means are used, shop personnel will repair around the trouble to avoid personal repercussions. Even then the repairs often miss the trouble. Both add up to the possible replacement of parts which may have many additional useful miles, or the making of unnecessary adjustments.

Statistics, which from long experience show the mileage expectancy of parts or assemblies, are important. Major failures can be reduced on items such as connecting rods or crankshafts which take valuable time when they fail. And yet the value of statistics can be easily over-rated. Skill in assembly and tolerance of parts used are not always going to add up to the same life expectancy for an engine or its individual accessories.

Statistics, to be safe, must therefore be graded down. Many units are reworked from 5 to 25% more often than required; and some fail or bring inefficient road operation many miles before reaching their normal replacement time.

Driver complaints, "shot-gun" diagnosis, and periodic replacements all have serious limitations. For economical maintenance there is no substitute for exacting diagnosis. Operators throughout the country report that exacting pin-point diagnosis is economically practical with the under-load method of testing. Of dynamometer users reporting, 100% use the dynamometer for diagnosing a large percentage of their fleet, and 69% report using the dynamometer for diagnosing all vehicles. See detailed report in Fig. 1.

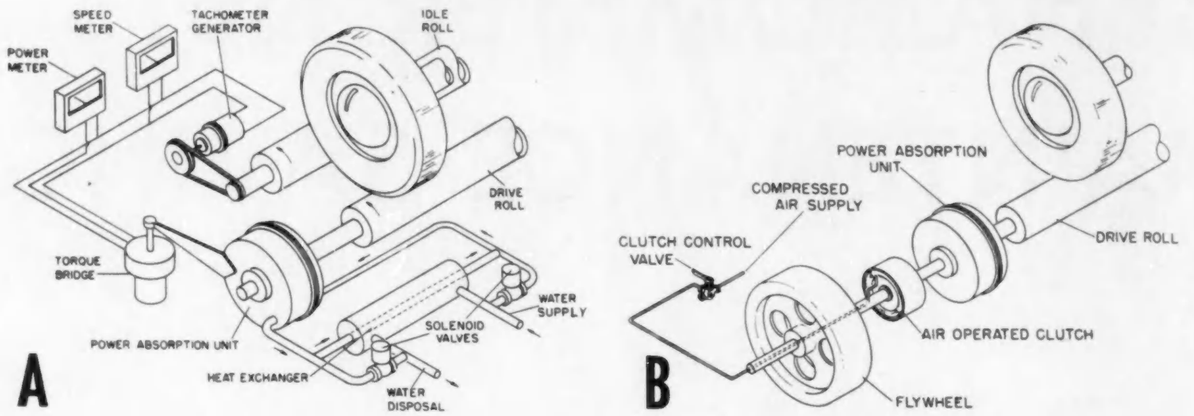
Need for the second item, after-repair inspection, brings little argument from the fleet operator. It just makes sense, if it can be done cheaply and reliably. Using the dynamometer as an after-repair inspection tool is endorsed by over 80% of the dynamometer users.

Since the nature of the repair work is known, check for quality can be made quickly. If only one accessory has been repaired, for example, test points which put this accessory through its paces can be selected and the job completed on a reported average of 2 to 5 min. (This procedure is entirely sound, particularly if the vehicle has been subjected to a complete diagnosis prior to the repair or just a few miles before.)

In case of extensive repairs, complete checking is desirable. This is more rapid than detailed diagnosis, especially if "par" pefrormance records have been established. A vehicle can be operated very rapidly at the four or five test points. Actual performance output is merely compared to "par," with smoothness and noise level observed. That is all there is to it.

In recent years practically all passenger car manufacturers have adopted chassis dynamometer inspections on the ends of their assembly lines. Com-

How the Chassis Dynamometer Works



Principal parts of the chassis dynamometer are schematically illustrated in "A" above. The vehicle wheel is cradled on drive and idler rolls. The drive roll turns the rotor of the power absorption unit which can be regulated to absorb power from substantially zero to maximum. Absorption of power generates heat which is dissipated by circulating cooling water through the heat exchanger.

The power absorption unit housing is mounted on cradle bearings. Mounted in this way, the housing tends to rotate with the rotor and at a force equal to torque input to the rotor from the drive roll. Movement of the absorption unit housing is is restricted by an arm which rests on a torque measuring device called a torque bridge.

An electrical tachometer generator, driven from the idle roll, generates current directly proportional to speed. This current is sent to the speed meter, which registers in miles per hour. Current from the generator also is sent through the torque bridge where the torque is measured electrically and combined with the speed, then sent to the power meters where it registers horsepower. This measurement is equal to the horsepower generated at the vehicle tire tread.

When so specified, dynamometers can be equipped with a flywheel, as in "B" above. The flywheel inertia is sufficiently equal to that of the test vehicle to permit coasting and acceleration tests, particularly advantageous in work on foreign chassis noises and automatic transmissions. Declutching the flywheel is necessary to permit rapid response of the dynamometer, desirable in engine testing.

plete inspection is done with several people at as rapid a rate as 1 min per vehicle. This is not cited as desirable speed for service operations, but does indicate what is being done when many vehicles must be checked.

In addition to the manifold advantages of placing a correctly repaired vehicle on the road, thorough after-repair checking has the great added feature of quality workmanship control. A few hours after the repair, discrepancies can be traced to their source and stopped before serious spread of similar incorrect practices. A means of measuring quality of repair saves arguments, gives personnel a mark to shoot at. Dynamometer users report the improvement in workmanship is of major importance and many claim improved morale.

Third dynamometer application, periodic visual inspections, leave much to chance. Periodic adjustments, whether needed or not, are wasteful. This is true now that vehicles can be put through a quick series of tests, designed to act exactly like the production Go and No-Go gage. By no means can either visual or periodic adjustments be entirely abondoned. The dynamometer can do nothing about steering, loose bolts, or body condition. But it does cover a multitude of troubles, some of which are listed in Fig. 2.

Most of these difficulties are tough to find consistently by visual inspection. They yield very reluctantly to life expectancy statistics, around which effective periodic service schedules can be established.

Here again, observation of system analyzing instruments, particularly if compared to approved standards, pronounces complete engine accessories satisfactory or at fault. For example, the exhaust analyzer can be quickly connected to carbureted vehicles and observed during the four dynamometer test conditions. It gives the story of carburetor basic mixtures, balance at part throttle, power stepup and when it comes in, as well as the customary no-load idle condition.

When compared with established standards of air-fuel ratio, malfunctions of the entire fuel system are found simultaneously with other tests; or the system can be pronounced satisfactory. Such quick Go and No-Go methods are not limited to the fuel system, but are carried through on the other accessories of both gasoline and diesel engines.

Most operators immediately fit a newly-installed dynamometers into their existing plans of periodic inspection. In many cases eventual decrease in frequency of inspection has resulted. In some, greater frequency has been economically adopted.

Depending upon the operation, they usually balance out at 2000 to 5000-mile intervals.

Study of the inspection sheets in the same way now normally practiced is the only sure way of getting proper frequency balance. When a large percentage of vehicle have litttle wrong with them, it is time enough to lengthen the period between inspections.

Establishing "par" performance records, conveniently filed, provides the surest way of reducing inspection time with the dynamometer. Little can be wrong with the powerplant or entire drive train when the operation is normally smooth, quiet, and power output is satisfactory. Considerable assurance against failure before the next inspection can be anticipated because all parts devoted to generating and transmitting power are tested under the severest normal road conditions.

Frequency of these maximum operating loads usually is small per mile of road operation. Therefore, a successful vehicle on the dynameter will average many miles before failure. Operators claim up to 75% reduction in road failures due to dynamometer inspection and diagnosis.

In a few cases, results far superior to no underload inspection have been realized by a so-called cross-section analysis. This procedure uses the dynamometer for very exacting determination of the condition of a representive number of vehicles. The findings are automatically used during the repair of the balance of the fleet.

Up to this point only major inspections have been considered. There is a growing tendency to use dynamometers even to the extent of installing an additional unit, for a so-called sifting or sorting out form of inspection. Objective here is to know at very frequent intervals whether the vehicle is fit for further efficient road service.

The test is simple. A card is usually placed in the vehicle which shows its acceptable road horsepower at a given speed. Each time the vehicle comes into the yard, or once a week, it is run across the dynamometer. The throttle is opened and the power compared to the accepted "par." If it does not, the vehicle is routed for diagnosis by the maintenance department.

This simple test can be conducted by the driver or any vehicle jockey, and serves well in sorting out those vehicles that can be expected to generate horspower efficiently from those that will have high road costs.

It is known that power can drop enough to influence fuel consumption adversely, yet not enough to prompt a driver complaint. Fuel consumption records take time to tabulate and only show increased consumption after it has occured. In the meantime the "horses" are eating too much.

Final Adjustments

Individual vehicle tune-up to point of peak power output is practiced by 84½% of dynamometer users. During the after-repair dynamometer check or the periodic inspection is the logical time to perform these final adjustments. By letting the engine speak for itself through maximum performance readings on the dynamometer horsepower meter, such adjustments as ignition, timing, or diesel fuel pump often produce worthwhile savings in fuel consumption, stack smoke, performance, and so forth.

These examples fall into the category of those adjustments which are affected by almost every variable of engine mechanical condition, climatic differences, and fuel quality. Any predetermined setting is a compromise. Making individual settings is practical from a time standpoint; but if a general program is adopted, care should be taken to see that the operators are familiar with all phases of the problem.

Some operators find it important to study improvements in operating economies resulting in deviations from factory standards. Since many vehicles must, for production reasons, be designed for statisfactory operation under widely diversified conditions, it is little wonder that work on axle ratios, timing, and fuel mixtures designed for a specific set of operating conditions brings improvement.

Desirability of such changes can only be proved after considerable study of extensive road mileages. The initial determination of combinations worthy of trial placement in scheduled runs can be greatly aided by the dynamometer. This places the service dynamometer in a similar category to the research machine.

I-ENGINE Power Output
- 1-COMPRESSION-Rings-Valveleaks-Valves sticking-Gaskets
- 2-CARBURETION-All stages of carburetor-Intake manifold-–fuel pump-Air cleaner
- 3-IGNITION—Automatic advance-Timing-Distributor-Coil-Spark plugs-High Tension wiring
- 4-FOREIGN NOISES-Rods-Mains-Pins-Pistons-Valves-Exhaust-Detonation
- 5-THROTTLE and GOVERNOR
- 6-FUEL-Rack-Injector-Pump
- + 7-STACK SMOKE
- + 8-COOLING-General condition-Thermostat-Shutters-Leaks
- 9-OIL-Pressure-Leaks

II DRIVE TRAIN
- 1-CLUTCH-Slip-Grab-Adjustment
- 2-TRANSMISSION-Noise-Automatic shift points
- 3-DRIVE LINES-Noise-Whip
- 4-LIVE AXLES-Noise-Gears-Bearings

III VEHICLE
- + 1-AXLE ALIGNMENT-"Bull Dogging" caused by broken springs, bent frame, etc.
- + 2-DRAGING BRAKES on live axles
- 3-GREASE-leaks
- + 4-REAR TIRES-Matching of duals-Alignment-Loose Tire Tread
- 5-SPEEDOMETERS
- 6-MUFFLER-loose-plugged-Bad Tail Pipes

+ *Items not commonly associated with Dynamometer work.*

Fig. 2—Fleet operators report that dynamometers are superior for diagnosis, inspection, or adjustment of these items

PACKARD'S NEW

Weds Torque

BASED ON PAPER* BY **Col. J. G. Vincent and Forest McFarland**
Vice-President of Engineering — Chief Engineer, Research Division
PACKARD MOTOR CAR CO.

THE new Packard Ultramatic transmission uses a torque converter for acceleration and direct mechanical drive for cruising. Coupled with a lower-than-standard axle ratio, this no-shift drive gives reasonably quiet acceleration, adequate performance for most driving conditions, and added performance when required.

We have attempted to give the driver maximum control over a unit which functions automatically. He has no clutch pedal to push, or gears to shift. The driver merely flips a control lever on the steering column to "P" for Parking, "N" for Neutral, "H" for High Range, "L" for Low Range, or "R" for Reverse. The automatic drive does the rest.

The engine can be started only when the lever is at Parking or Neutral. Parking holds the car on hills, positively locking the rear wheels. High Range is for all normal driving, Low Range for unusually steep grades, maximum acceleration, or downhill braking. The driver can rock his car out of ruts or bad spots by just flipping the lever back and forth from Low Range to Reverse.

Dead Battery Starting

In case of a dead battery, push starting is easy. The driver merely keeps the lever at neutral position until the car is moving about 25 mph. Then he slips the lever to High Range, which starts the engine.

The driver is never "handcuffed" to the torque converter or the direct drive. He can use one or the other as he pleases or requires. For a fast getaway, he presses hard on the accelerator; the Ultramatic Drive stays in torque converter until the car reaches 55 mph, when it shifts automatically into direct drive. Between 15 and 55 mph shift into direct drive occurs automatically, depending upon accelerator position.

General Description

The transmission, shown in section in Fig. 1, consists of a torque converter with planetary gearing. One clutch and two brakes are arranged to obtain the high range which is a straight-through drive, and low range and reverse which are geared drives. Converter or direct mechanical drive operates in either range.

Starting is through the torque converter in either range, with automatic shift into direct mechanical drive by application of a single plate clutch, governed by car speed and accelerator position. Converter operation can be obtained when in direct drive at any time in high or low range under top governed speed by "kicking down" the accelerator as on overdrive cars. The two ranges and reverse are obtained by a clutch and brakes, with no gear tooth engagement.

Fig. 1 shows the construction in detail and Fig. 2 an external view of the installation.

A flexible disc is mounted on the crankshaft and bolted to the direct-drive clutch housing which, in turn, is attached to the converter pump that has a rear extension driving the front oil pump. The converter turbine, or driven member, is attached to a hub also carrying the direct clutch member and damper.

The direct clutch is located just ahead of the con-

* Paper "Packard Automatic Transmission," was presented at SAE Summer Meeting, French Lick, June 8, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

ULTRAMATIC DRIVE

Converter to Gears

That
That
That

verter turbine. The hub carrying these two members is splined to a shaft, the rear end of which is splined to the rear sun gear of the planetary train. This shaft also carries a hub driving the plates of the high range clutch.

The reactor is mounted on a sleeve which engages with a one-way sprag clutch mounted in the housing rear of the front oil pump.

The planetary gearing is of a familiar type. Double pinions mounted in a cage attached to the final driven shaft meshing with two sun gears and a ring gear, provide an underdriven low ratio of 1.82 by braking the forward sun gear, and a reverse ratio of 1.64 by braking the ring gear. High range is obtained by locking the sun gears together by the high range clutch.

The controls and the cylinders for operating the brakes are attached to the bottom of the center case for easy removal. A helical gear located back of the rear oil pump drives the governor and speedometer gears. The governor is located on the right side of the case and can be removed as an assembly. Rearward of the governor is a parking gear with an actuating sprag underneath.

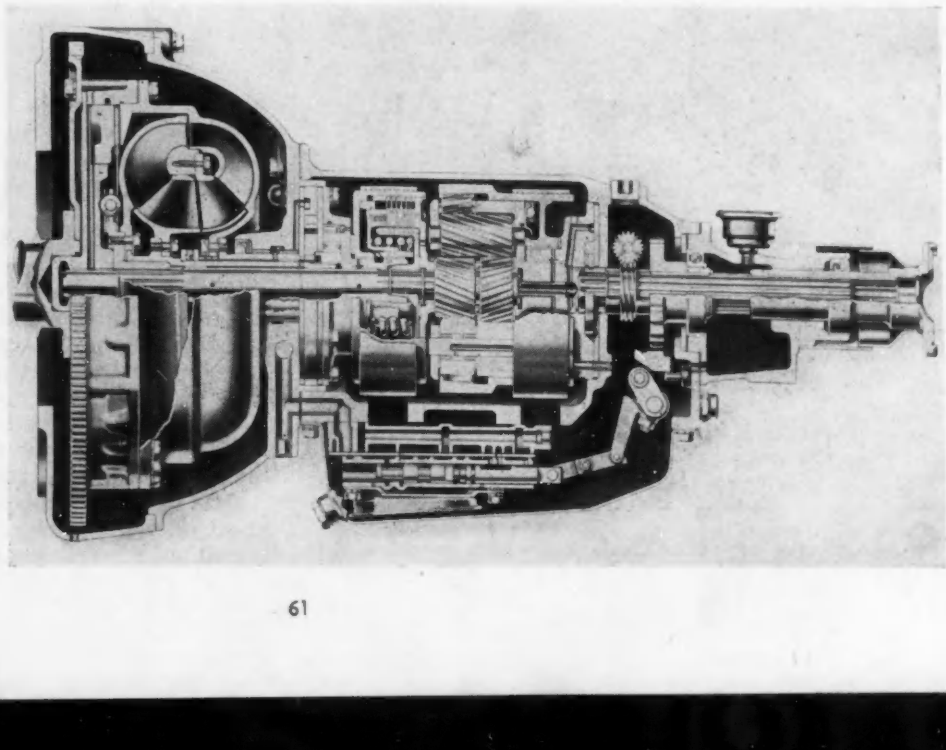


Fig. 1—Cross-section of the Ultramatic transmission showing construction

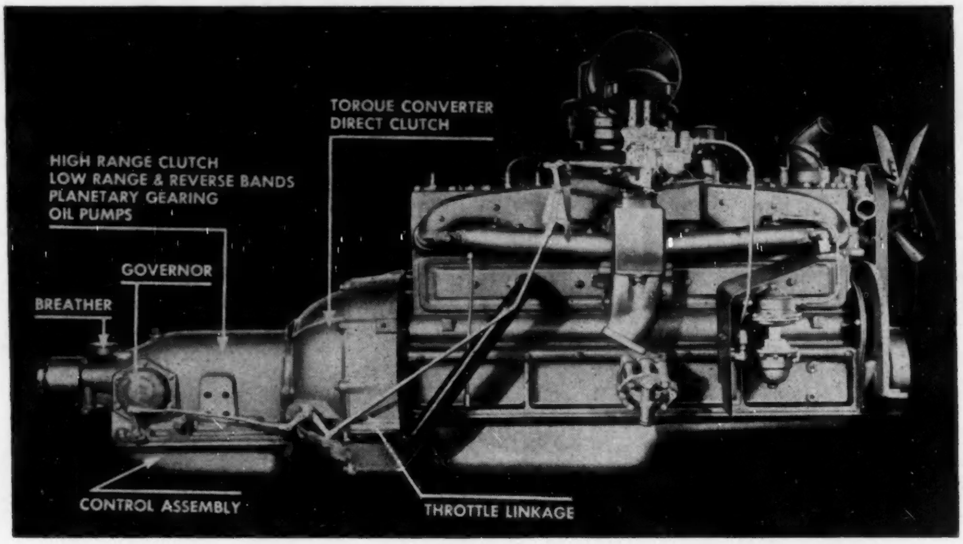


Fig. 2—The Ultramatic Drive installation

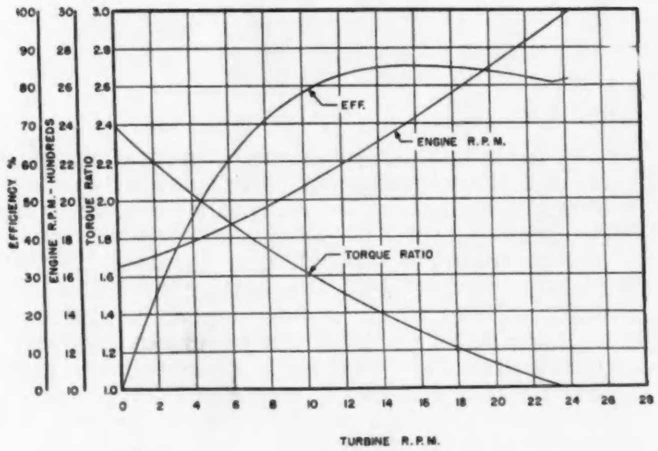


Fig. 3—Performance curves of the Ultramatic torque converter

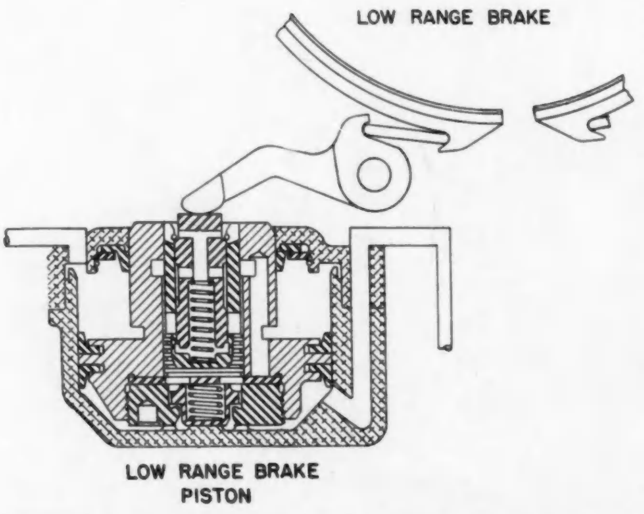


Fig. 4—Fast-acting type pistons actuate the low range and reverse brakes

Our first step in the converter development was the design and construction of a converter of the conventional three-unit type. The performance of the completed unit agreed very closely as to torque and speed with the calculated results. The immediate drooping of the pump speed from the stall value, and the short span of the conversion range, immediately gave rise to an intensive study and development program.

The characteristics desired were a reasonably low stall speed, a satisfactory stall torque, a sharply rising pump speed curve, and a turbine coupling point extended well out on the turbine speed curve. A reasonably high efficiency and a fair degree of quietness were also desired.

Analytical study and development work resulted in the form shown, which has a performance pattern as shown in Fig. 3. It will be noted that all of the objectives desired have been attained to a satisfactory degree.

The size of the unit may surprise many. The outside diameter of the mean path of flow is 10 in.

Blading Design

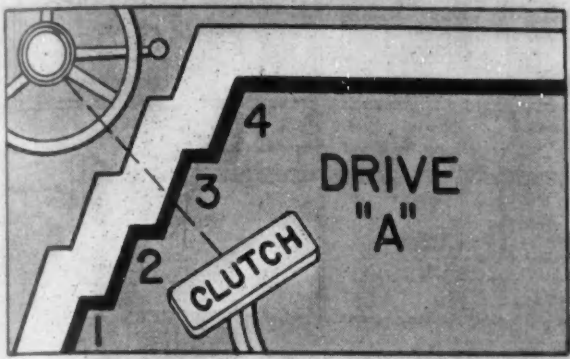
Our analysis and test results indicated that pump blading, substantially radial, was one of the design features desirable to maintain proper flow and extend the coupling point of the unit. The design of the pump and that of the blading in the other members established the size shown to obtain the desired stall speed.

The two-stage turbine construction is of special interest. This arrangement, along with other design considerations, has produced a steeply rising engine speed curve with the resultant extended coupling point.

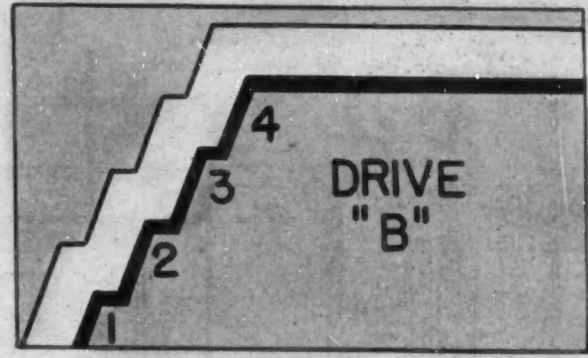
Location of the blading of the second turbine assists the pump in developing the necessary hydraulic head to obtain the required fluid flow rate.

The type of pump speed curve shown is felt to be most pleasing to the driver, since increase of engine speed with increase of car speed is not as noticeable

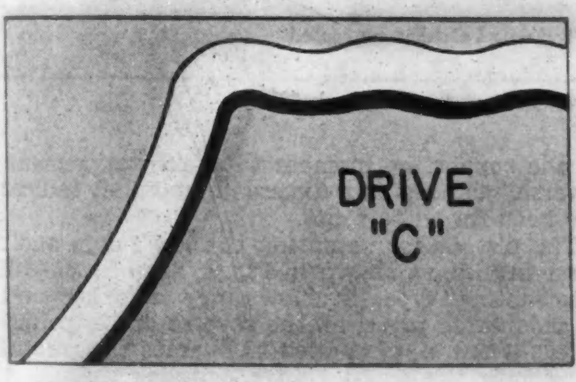
Evolution of Self-Shifting Drives



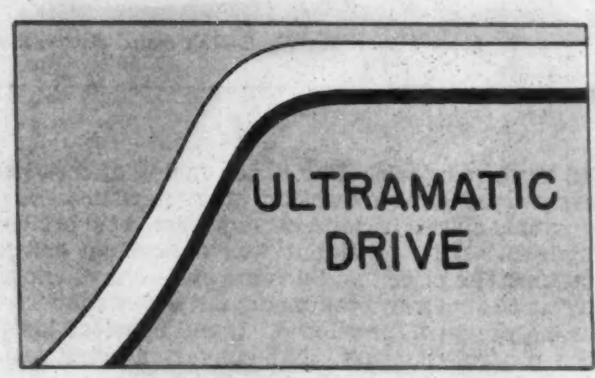
1939—Drive "A" employed a fluid coupling plus conventional clutch, operated by foot pedal. Two-speed semi-automatic transmission provided four forward speeds. Clutch pedal and gear shift lever had to be used to shift from low-range to high-range. In either range, it was necessary to release pressure momentarily on the accelerator in order to change gear ratios.



1940—Drive "B" employed a fluid coupling plus four-speed automatic transmission. No clutch pedal. The fluid coupling transmitted the engine's "twisting effort" (torque) directly to the transmission, where it was stepped up or down through a system of planetary gears. Gear-shifting was performed entirely by the transmission.



1948—Drive "C" was the first of the modern "curve-type" drives. It employed a hydraulic torque converter, which provides an infinite range of "gear ratios" without use of gears, and thus eliminates need for an automatic transmission. No clutch pedal. In this design, the car was driven through the torque converter at cruising speeds, as well as during acceleration.



1949—*Packard Ultramatic Drive* employs a torque converter for smooth acceleration—and mechanical drive for slippage-free cruising. Dual-range transmission offers a choice of low range or high range operation—with torque converter acceleration, and solid mechanical-drive cruising, in each range. No clutch pedal. Automatic controls switch from torque converter to direct drive.

as a high initial stall speed.

Blading in this unit consists of vanes with rounded leading edges and sharp trailing edges and non-uniform sections, with the thickness in the sections designed to suit the flow and area problems encountered in each member of the unit.

One of the problems in a development of this type is the time for fabricating parts. Experimental parts were made of stampings in our experimental shops in less time than castings could be obtained. The production parts on the first model are aluminum castings, as original tooling and changes appear to be less of a problem than with the stamped design, which appears interesting for high production.

Units Detailed

Referring again to Fig. 1, the direct clutch ahead of the converter engages the pump and housing assembly to the output drive shaft at the speed indi-

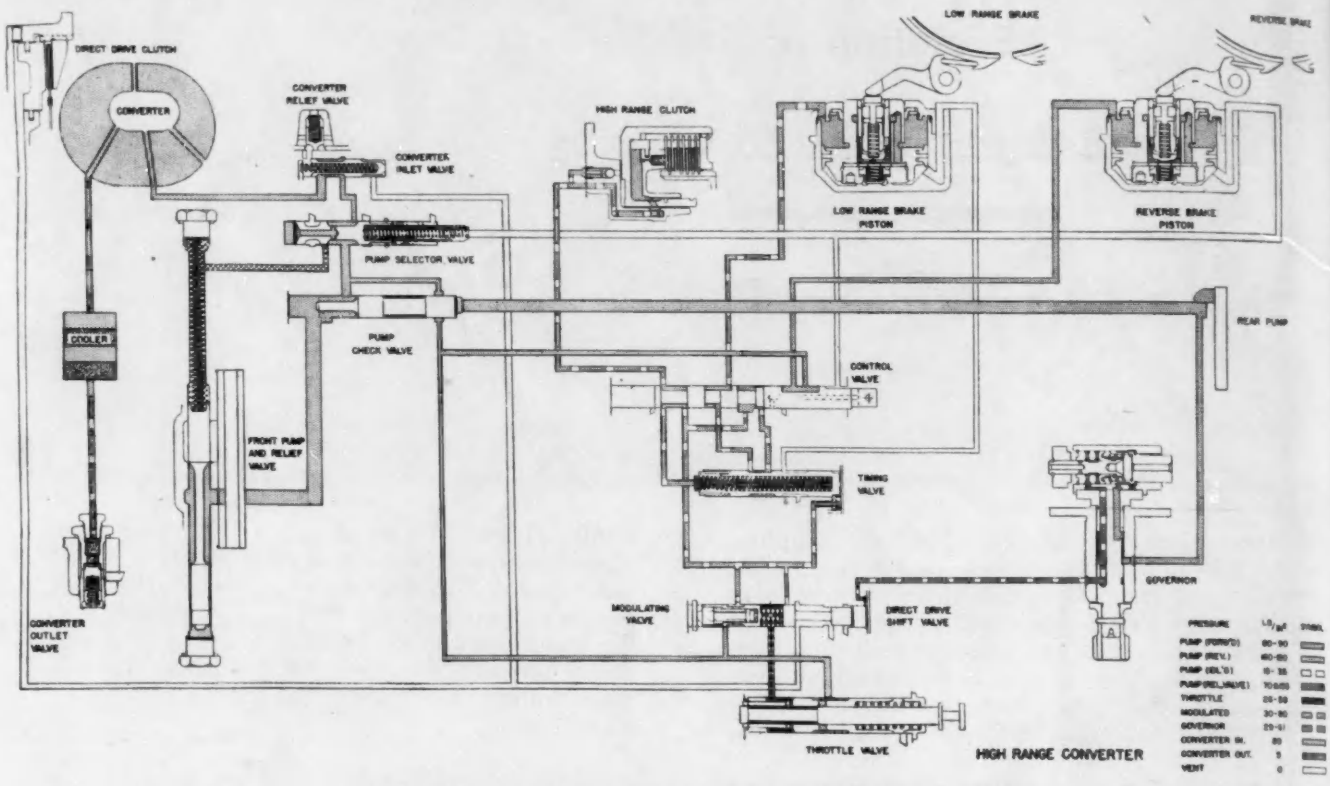


Fig. 5—This control diagram shows how brakes and clutches are applied

cated by the controls. The clutch facing of cork has shown very desirable friction characteristics. Engaging this clutch in solid oil has offered no serious difficulties. Disengagement was a problem solved by making the piston and driving plate one member, grooving the cork and taking advantage of converter charging pressure for release. It will be noted later, in the control diagram, that converter pressure is reduced to a low value when in direct drive to avoid reduction of capacity of the direct clutch.

The elastic system rearward of the direct clutch is of interest; the inertia of the turbine assembly, with respect to the torsion shaft, is sufficiently high, and the spring rate of the clutch damper is sufficiently low to bring the fundamental mode of the driven system just below the point of direct clutch engagement.

The gearing is of the helical type of 20-deg pressure angle, 20-deg helix angle, 14.9 normal pitch with addendum height modified to balance the action, and with involute contact ratio of the order of 1.4 and helical contact ratio of the order of 1.8. The driving sides of the gear teeth are true involutes. The driven sides of the teeth are true involute inside the pitch line and modified an average of 0.0004 in. at the tip of the teeth. This modification is in line with our previous practice on our standard transmissions, except the amount is small compared to our standard modification.

The high range clutch is of conventional form, using cork and composition type of plates. The clutch has vent holes in the piston and an air bleed in the supporting member to avoid engagement in reverse. Testing on a fixture immediately indicated the need for these vents.

The pistons for actuating the low range and reverse brakes, as shown in Fig. 4, are of a so-called "fast-acting" type. The low range brake is operated by modulated pressure, the reverse at 170 psi pressure. When oil is applied to operate the piston, it flows into the small center cylinder through the check valve, immediately forcing the small piston to take up the band clearance. An instant later, the large piston starts to move upward, forcing the oil above the piston out through a restricted vent in the small position, opened after the band clearance is taken up.

When the large piston has barely left its seat, the check valve in the center closes, trapping the oil in the small center cylinder, permitting the large piston to actuate the brake through the trapped oil and small piston. The restricted vent softens the action of the piston yet still keeps the action fast. The reverse piston is exactly the same as low range, except the pressure is 170 psi.

The method described permits fast, soft action, enabling the driver to rock the car readily.

The brake bands are formed out of tubing with copper-brazed actuating lugs and lined with cemented semi-metallic lining. Testing to date has indicated little trouble with the brazing procedure which greatly simplifies processing.

Rearward of the planetary gearing is the rear oil pump used for starting, and supplying oil at higher

speeds when the front pump is at idling pressure. Next are the speedometer and governor, driven from the same driving gear.

Rearward of these gears is the parking gear and actuating sprag. Movement of the lever to the Park position engages the sprag through a torsion spring which permits completing of shift even though the teeth abut. This method of engagement is similar to the reverse shift used for years on our overdrive.

Controls

The method of applying the clutches and brakes is shown in the control diagram in Fig. 5. The various positions of the selector lever locate the control valve in a position to cause oil flow to the proper actuating unit.

In Neutral and Park, oil is applied to the top of the low range and reverse pistons to provide full release. The high range clutch is vented. An electrical contact, made by a switch actuated by the detent lever, permits starting the engine in these positions only.

In High Range, the control valve permits oil to actuate the high range clutch by modulated oil pressure proportional to throttle opening.

Starting is, of course, in converter with the direct clutch engaging when the governor pressure, approximately proportional to speed, slightly exceeds the throttle pressure proportional to throttle opening. This shifts the direct-drive shift valve, thereby energizing the direct clutch.

The governor is of the centrifugal type with the usual parabolic pressure sheared curve upward by addition of a spring to assist the governor weight. The resulting curve somewhat approximates a straight line.

The valve at the opposite end to the pressure control value is a centrifugal venting value which cuts the governor pressure in at approximately 15 mph and definitely vents the shift valve at approximately 13 mph. This valve insures definite disengagement of the direct drive clutch at the proper time when coming to a stop. One point of interest in the throttle valve is that there is no reaction on the accelerator operating linkage, even though the pressures are sizable.

In Low Range and Reverse, the control valve energizes each piston respectively as previously described. Direct drive is obtained in Low Range as in High Range, permitting extended hill climbing in either range without use of the converter. In Low Range, hill descent is also made with the engine positively connected to the gearing.

Shift from Low to High Range, made by the steering column lever, is accomplished by the timing valve. When the high range clutch pressure reaches a value indicating start of engagement of the clutch, the valve moves to the right, releasing the low range brake and positively disengaging it through oil applied to the top of the piston. Lag of this valve is accomplished by metering the oil displaced by the valve. Shift from High to Low Range is similarly delayed by the time interval of travel of the valve to the left to prevent premature engagement of the brake. This is particularly needed when accelerating to avoid an objectional torque reversal due to engagement before the engine has risen to 1.8 times its speed in high range.

Oil flows through the converter and cooling system at a calibrated rate and under pressure originating at 85 psi in the selector valve chamber, flowing through the converter inlet valve to the converter, then through the cooler and returning to the transmission case through the converter outlet valve set at 5 psi. The converter pressure is somewhat under the 85 psi pump pressure due to the pressure drop between the selector valve chamber and the converter. When the direct clutch is applied, the direct converter feed through the inlet valve is cut off and the converter is fed by leakage through various bushings of a fairly well-established but a definitely smaller amount.

Flow to Converter Controlled

This system permits high pressure and high flow in the converter when it is operating, but low pressure and low flow when not needed, facilitating direct clutch operation. When shifting into direct drive in cold weather, an additional blowoff valve is provided next to the inlet valve to reduce quickly the converter pressure to insure positive engagement of the direct clutch.

When sufficient car speed has been attained in direct drive, the rear pump moves the pump check valve forward, increasing the pressure in the pump selector valve. This cuts off the oil assisting the front pump relief valve spring. The pump check valve then moves forward to seal the front pump from the selector valve chamber, permitting the front pump to idle at approximately 25 psi, which conserves power and heat rejection.

Location of the relief valve adjacent to the front pump reduces the idling pressure more effectively than where the valve is remote from the pump, by eliminating frictional flow resistance.

Reverse pressure is raised to 170 psi by oil in reverse fed to the back of the selector valve on an area equal to half the normal valve area.

This is considered a progress report. We feel there is much work left to be done on this complex development.

Acknowledgment

Proper acknowledgment to all individuals concerned with this project would be difficult. The converter development has been directly handled by H. L. Misch, assisted by W. G. Bopp; gearing and general stress work by G. H. Joly; controls by C. J. Lucia and H. W. Stephens.

The release of engineering information to the Production Division has been handled by the Automotive Division under J. R. Ferguson and E. A. Weiss, with the advice of R. E. VanDeventer on metallurgical considerations.

Fabrication of parts and endurance testing have been handled by the Automotive Testing Department under E. H. Smith, assisted by the Proving Ground group in testing, and W. F. Pollack in fabrication of parts.

The teamwork of the men not listed in all of the above divisions, together with the cooperation of our suppliers, have also assisted greatly in this program.

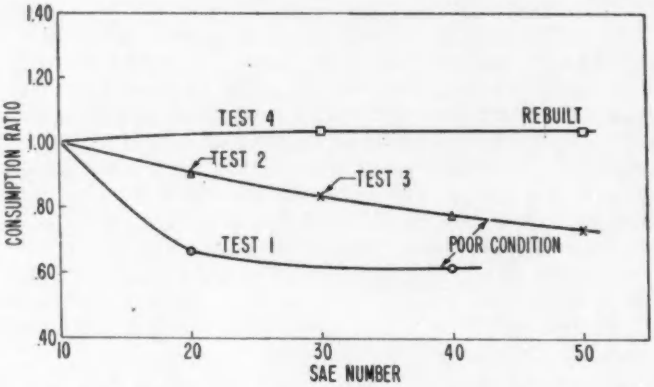


Fig. 1—Tests 1, 2, and 3 shows that for an older engine oil consumption goes down as viscosity goes up. For the rebuilt engine in Test 4, oil viscosity has little effect on oil consumption

How Oil Engine

PRELIMINARY results from tests evaluating effects of viscosity of engine oil, including 2-104B heavy-duty oils ranging from SAE 10 to SAE 50 and a 5W grade, showed that:

1. Oil consumption increases as oil viscosity decreases, differences becoming more pronounced as engine mechanical condition becomes poorer.
2. Engine sump and main bearing temperatures increase with oil viscosity, becoming excessively high with SAE 50 grade.
3. Friction horsepower increases slightly as oil viscosity increases, but to such slight degree that it is unnoticed in actual car operation.
4. Engine wear from mechanical causes is little affected by oil viscosity. But improper use of a very light oil, such as 5W, may cause increased piston ring wear when ambient temperatures are high.
5. Oil deterioration increases as viscosity decreases, but petroleum ether insolubles—a measure of contamination—appears independent of viscosity. Length of service directly affects petroleum ether insolubles.

Oil Consumption

Two 6-cyl passenger car engines were used in the laboratory consumption tests—a 1940 model in poor mechanical condition after running 75,100 miles in an automobile, and a newly rebuilt 1942 model which had been used solely for laboratory work. Two series of tests, approximately a year apart, were run on the former, and one series on the latter. The engines were not disturbed mechanically during any one series of tests.

Each test was 10 hr long. Cooling water outlet temperature was held at 170 F, but no attempt was made to hold oil temperature at any predetermined level. To get maximum reliability of consumption data, the drain plug was removed after each test while the engine was still hot and the oil was allowed to drain for one hour.

Consumption figures were reduced to a ratio basis, using the consumption of the SAE 10 grade as unity in each case. This eliminated any variations due to use of different speeds for the different series of runs. The speed, of course, was held constant during the several runs made to compare consumption of the oils of different viscosities comprising any one curve.

Fig. 1 indicates the results obtained with oils SAE 10 through 50. Tests 1, 2, 3, for the older engine, show a definite reduction in consumption with increase in viscosity. Consumption ratio varied appreciably from one series of tests to another, as is apparent from the spread between Test 1 curve and the curve for Tests 2 and 3. This may be ascribed to the poorer condition of this engine during test run No. 1.

The curves for Tests 2 and 3, derived from a series of runs at two different speeds, coincide. Actual consumption, as is to be expected, was higher at the higher speed; but using the relative consumption idea makes these two curves identical.

Test 4 refers to the rebuilt laboratory engine. The curve obtained indicates that oil viscosity within the range used has very little effect on consumption in this engine, because of its good condition. Since only one engine is involved, such a conclusion obviously should not be applied generally.

As shown by Fig. 2, based on L-4 tests, consumption results from a number of engines show no appreciable differences until relatively low viscosities are involved. Consumption with SAE 10 grade is higher than for heavier grades.

Fig. 2 also shows a datum point for 5W oil and for a relatively, light-bodied hydraulic fluid. Crankcase oil temperatures were held at 250 F for the hydraulic oil, at 265 F for the 5W and SAE 10-10W, and at 280 F for all higher viscosity oils. Inspection of the complete curve leads to the conclusion that oil consumption may be expected to increase rapidly when oils lighter than SAE 10 grade are used. The probable reasons are not difficult to discern; low-

Viscosity Affects Performance

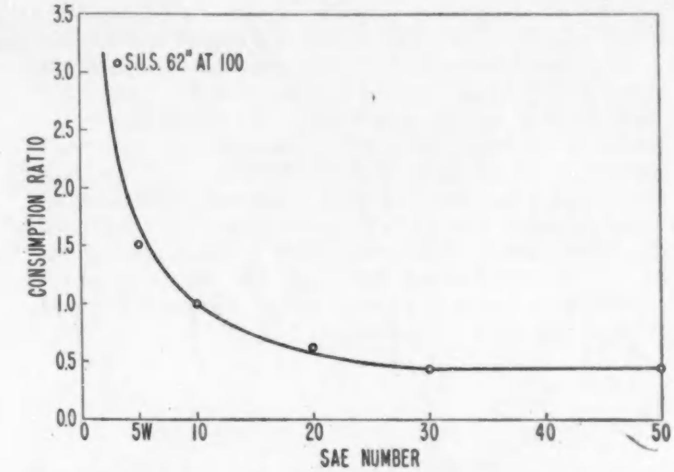


Fig. 2—L-4 tests with several engines indicates no appreciable difference in consumption until relatively low viscosity oils are used

EXCERPTS FROM PAPER* BY

J. W. Lane

Manager, Automotive Division, Lubricating Department
Socony-Vacuum Oil Co., Inc.

and D. S. Chatfield

Technical Service Department,
Socony-Vacuum Laboratories

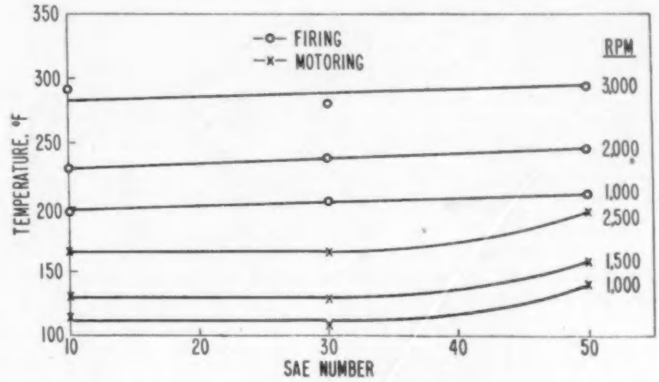


Fig. 3—Sump temperatures of a 6-cyl car engine versus oil viscosity

viscosity oils escape more readily past the rings and are also more readily volatilized.

Engine Temperatures

Sump and main bearing temperatures were determined during the consumption tests on the rebuilt laboratory engine, and later in motoring tests (dynamometer driving engine) at various speed levels. During motoring, cooling water outlet temperature was held at 70 F, but no attempt was made to regulate oil temperature. During each test, sufficient time was allowed for temperatures to stabilize before any measurements were recorded.

Figs. 3 and 4 show, respectively, sump temperature and main bearing temperature versus oil viscosity, under both firing and motoring conditions at different speeds. At all speeds, temperatures rose with an increase in oil viscosity, indicative of the

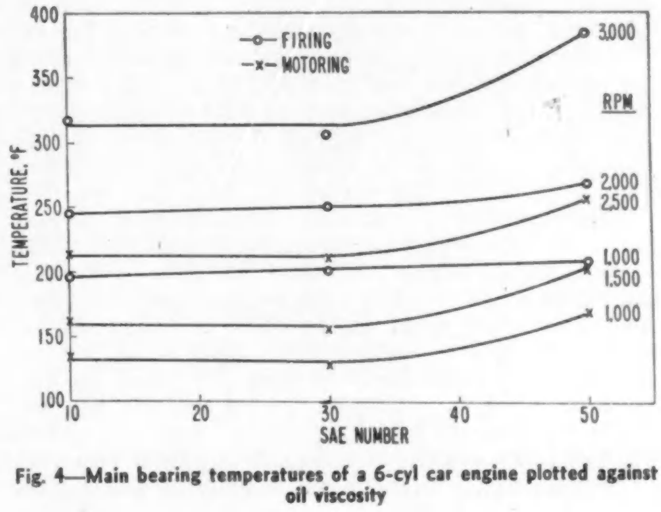


Fig. 4—Main bearing temperatures of a 6-cyl car engine plotted against oil viscosity

* Paper "Effect of Lubricating Oil Viscosity on Engine Performance," was presented at SAE Summer Meeting, French Lick, June 6, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

greater energy necessary to shear the increasingly viscous films.

Under firing conditions, the curves of sump temperature are relatively flat, so that the spread between the lowest-viscosity oil and highest-viscosity oil is a somewhat smaller value than is the case for the motoring runs.

A similar result is evident for main bearing temperatures at the low (1000 rpm) and medium (2500 rpm) speeds. However, at the highest speed (3000 rpm), the difference in main bearing temperatures from grade to grade is at a maximum.

Inspection of these curves seems to indicate (for the make of engine involved) that use of a heavy oil, especially on an SAE 50 grade, in a new or newly-rebuilt unit would be attended by excessive main bearing temperatures. This would not only hasten oil deterioration by oxidation, but would produce undesirable mechanical effects on the bearings—such as reducing hardness and strength, especially under critical operating conditions.

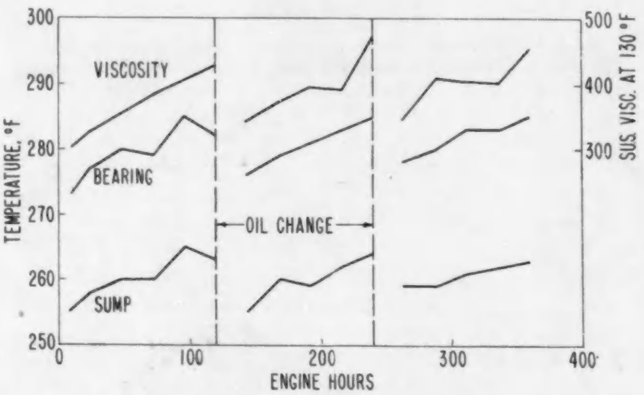


Fig. 5—These curves show the effect of oil viscosity on engine sump and main bearing temperatures after 360 hr of operation, with oil drained at 120 and 240 hr

To determine the results to be expected from an extended period of use, a 6-cyl truck engine was operated for 360 hr, with oil drains and refillings at 120 and 240 hr. Speed and load were constant throughout the entire test period; engine cooling water outlet temperature was 180 F. Saybolt viscosity at 130 F and main bearing and sump temperatures were determined at several intervals in the life of each charge. The resulting data are shown in Fig. 5.

The curves are practically self-explanatory. As oil viscosity increased as a result of oxidation, sump and main bearing temperatures also increased. After each oil change, temperatures dropped back, but never quite reached the value recorded shortly after start of the run on the original charge. This may be attributed to the "hung-up" used oil and contaminants which could not be entirely drained from the engine at the 120-hr and 240-hr oil changes. Fluctuations from the upward trend in viscosity and temperatures are believed due to fuel dilution of the lubricant.

The abrupt temporary increase in temperatures as the 100-hr mark was approached cannot be explained satisfactorily with the data available and should be discounted.

Friction Horsepower

Determination of friction horsepower only was made to eliminate carburetion and spark-timing variables encountered in power output evaluations. The test set-up comprised the rebuilt 6-cyl passenger car engine and a dynamometer used to motor the engine at the several speeds used in testing each of the oils.

Each speed was maintained sufficiently long for oil temperatures, regardless of the level it attained, to become stabilized. Cooling water temperature was held at 70 F at all speeds to accentuate the effect of oil viscosity on friction horsepower.

Results obtained appear in Fig. 6, showing percent change in friction horsepower (FH_p) plotted against SAE number at four different speeds. As expected, FH_p increased as viscosity increased. The percent increase became increasingly greater as speed dropped, being almost 45% at 1000 rpm with the SAE 50 oil as compared to the SAE 10. Contrasted with the comparable increase of 18% at 2500 rpm,

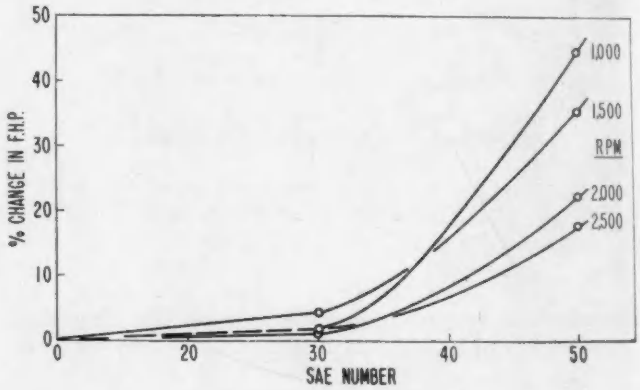


Fig. 6—How oil viscosity affects the friction horsepower of a 6-cyl car engine at different speeds

the 45% increase noted is two and one-half times as great as that at 2500 rpm.

It is well to recall that actual power output is small at low speeds, and even a small increase in friction horsepower means a relatively high percentage increase. Furthermore, at the higher engine operating temperatures prevailing after warm-up is completed, the percentage increases will be much less than at the 70 F jacket temperature used for these tests.

These curves further support the conclusion that SAE 50 oil is much too heavy for this make of engine. The additional friction horsepower, say over that attendant on use of an SAE 30 grade, manifests itself merely in higher temperatures, as already

demonstrated by Figs. 2 and 3. The practice would waste fuel and harm the lubricant.

Engine Wear

Very little data are available on which to base conclusions regarding wear. That which can be used was taken from routine 36-hr L-4 tests. In general, it can be said that oil viscosity, within the range of grades customarily used, should have no appreciable effect on the rate of wear in this particular engine.

In one group of tests with SAE 30 oil, ring gap increase varied from 0.002 to 0.014 in., and bearing weight loss from 28 to 248 mg, averages of each being 0.0055 in. and 106.7 mg, respectively. For the SAE 10 oil, bearing weight loss varied from 51 to 173 mg, the average being 112.3. The latter figure is so close to the 106.7 mg average value for the SAE 30 oil that the small difference involved must be viewed as insignificant.

It is difficult to develop from this particular data any conclusion regarding relationship between wear and viscosity. On the assumption that the oils each afford equal protection against corrosion and that the bearing weight loss represents wear, it may then be considered that the difference in protection against wear provided by an SAE 10 and an SAE 30 oil is not detectable by these tests.

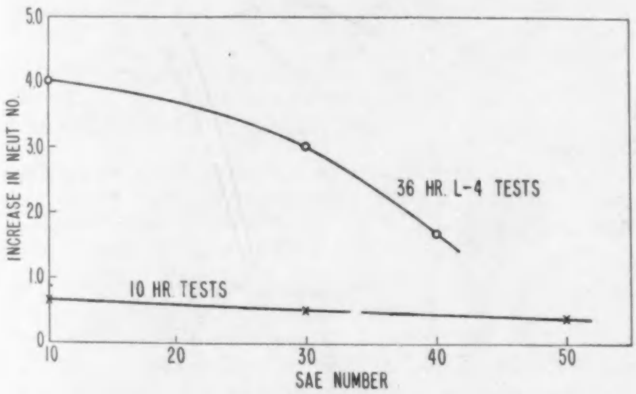


Fig. 7—These tests show that oil deterioration speeds up as its viscosity decreases. Difference between grades becomes more pronounced with increase in oil temperature. Temperatures for the 36-hr tests were 20 F higher than those for the 10-hr tests

The present interest in the extremely light-bodied oil 5W naturally has focused attention on the possibility of abnormal wear in engines using this grade. Data taken from L-4 tests, conducted at 265 F sump temperature for the 5W oil shows the average ring weight loss per piston, in grams, is about 80% higher for the 5W oil than for the averages of seven runs on SAE 10 and eight runs on SAE 20.

For all practical purposes, no significant difference exists between the results with SAE 10 and SAE 20, while the wide range in values obtained with the 5W (from a low of 0.053 to a high of 0.710) suggests that even with this light oil, wear may depend principally on the individual engine rather than on the oil viscosity. Use of a 5W oil does, however, reduce the factor of safety as far as protection against wear is concerned at high temperature.

Oil Deterioration

These data were secured from routine 36-hr L-4 tests, from modified 66-hr FL-2 tests, and from the 10-hr oil consumption tests discussed.

Results are shown in Figs. 7 and 8. Fig. 7 reveals that oil deteriorates more rapidly as oil viscosity decreases, even though the lower-viscosity oil operates at a lower temperature. It must be emphasized that this should be accepted only for oils containing identical amounts of the same oxidation inhibitor, which is true for the SAE 10 to 50 oils used in these studies.

It is also obvious that as operating temperatures increase, the difference in deterioration between grades becomes more pronounced; the upper curve for the 36-hr tests represents oil temperatures 20 F higher than those prevailing for the 10-hr tests of the lower curve. The longer period of service also increases the deterioration. But this factor is less important than oil operating temperature, which is very well demonstrated in Fig. 8. This is a plot of increase in neutralization number against engine hours for SAE 30 oils operated at 280 F and 170 F. The increase in neutralization number is several hundred percent greater at the higher temperature.

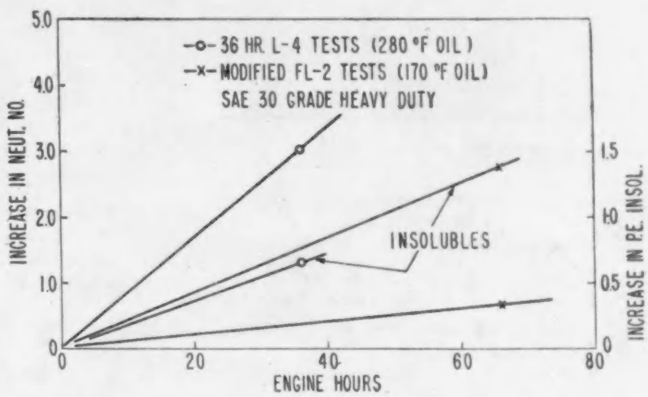


Fig. 8—Higher temperatures accelerate oil deterioration much more rapidly than does length of service, according to these test results. Petroleum ether insolubles, a measure of oil contamination, appear to depend on length of service rather than viscosity

On the other hand, oil viscosity has no apparent effect on the amount of contaminants in the oil, as long as blowby is reasonably well controlled. The amounts of insolubles vary considerably and appear independent of viscosity. Length of service and type of service are doubtless the controlling factors. The plots of percent petroleum ether insolubles, shown in Fig. 8 for SAE 30 oils, indicate that length of service is the predominant factor. These data emphasize the desirability of frequent oil changes and the disadvantages of over-extending oil change periods.

SAE National AERONAUTIC

Hotel Biltmore, Los Angeles, Calif.

WEDNESDAY, Oct. 5

All-Day Inspection Trip

Southern California Cooperative Wind Tunnel and Hydrodynamics Laboratory, California Institute of Technology, Pasadena, Calif.

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(Sponsored by the SAE Southern California Section through the cooperation of the California Institute of Technology)

THURSDAY, Oct. 6

10:00 a.m.

Welcome—C. F. THOMAS, General Chairman of the Meeting

WILLIAM LITTLEWOOD, Chairman

A New Appraisal of the 1955 Air Transport

Engine Manufacturer's Viewpoint
—D. J. JORDAN, Pratt & Whitney Aircraft Division, United Aircraft Corp.

Canadian Manufacturer's Viewpoint
—E. H. ATKIN, A. V. Roe Canada Ltd.

Airplane Manufacturer's Viewpoint
—A. E. RAYMOND, Douglas Aircraft Corp.

Airline Operator's Viewpoint
—H. R. HARRIS, American Overseas Airlines

(Sponsored by Air Transport Activity)

2:00 p.m.

G. W. NEWTON, Chairman

Sand and Dust Erosion in Aircraft Gas Turbines
—J. E. DeREMER, Air Materiel Command

New Approach to Axial Compressor Cascade Testing Technique
—J. R. ERWIN and J. C. EMERY, National Advisory Committee for Aeronautics

Practical Conclusions on Gas Turbine Spray Nozzles
—D. R. GANGER and F. C. MOCK, Bendix Products Division, Bendix Aviation Corp.

(Sponsored by Aircraft Powerplant Activity)

PRODUCIBILITY PANEL DISCUSSIONS

Four Panels—THURSDAY evening and all day FRIDAY
General Chairman—D. R. SHOULTS, The Glenn L. Martin Co.

8:00 p.m.

F. C. CRAWFORD, Chairman

Basic Problems of Producibility

Definition and Need for Producibility
—MAJOR-GEN. F. M. HOPKINS, JR., USAF, Chief, Industrial Planning Division, Air Materiel Command

Need for Improved Performance
—REAR-ADMIRAL A. M. PRIDE, USN, Chief, Bureau of Aeronautics

Airframe Manufacturers' Problems and Solutions
—H. L. HIBBARD, Lockheed Aircraft Corp.

Engine Manufacturers' Problems and Solutions
—E. B. NEWILL, Allison Division, General Motors Corp.

(Sponsored by Aircraft Activity)

FRIDAY, Oct. 7

10:00 a.m.

F. L. MAGEE, Chairman

Significant Structural Design and Fabrication Developments

Military Significance of Large Pressure Forgings
—MAJOR-GEN. K. B. WOLFE, USAF, Director, Procurement and Industrial Mobilization, Air Materiel Command

Meeting

and Aircraft Engineering Display

OCT. 5-8

The Importance of Tapered Sheet and Large Pressure Forgings in Modern Wing Design
—S. J. PIPITONE, The Glenn L. Martin Co.

Required Production Facilities for Large Pressure Forgings
—G. W. MOTHERWELL, Wyman-Gordon Co.

(Sponsored by Aircraft Activity)

2:00 p.m.
R. F. GAGG, Chairman

Optimum Engine Producibility

Maximum use of Subcontracting—Philosophy of Lockland Plant Operation
—K. N. BUSH, General Electric Co.

Blade Design and Production
—A. T. COLWELL, Thompson Products, Inc.

Expediting Production through Sub-Assemblies
—R. P. KROON, Westinghouse Electric Corp.

Precise Methods of Fabricating Sheet Metal Parts
—W. C. HEATH, Solar Aircraft Co.

Maximum Usage of Test Facilities
—W. P. CROSS, Pratt & Whitney Aircraft Division, United Aircraft Corp.

(Sponsored by Aircraft Powerplant Activity)

8:00 p.m.
D. W. RENTZEL, Chairman

Presentation of Manly Memorial Medal to ANDREW KALITINSKY by C. T. DOMAN, Chairman, Manly Memorial Board of Award

Interchangeability of Military and Commercial Transports

Standardization and Certification
—W. E. BEALL, Boeing Airplane Co.

The Applicability of Civil Air Regulations to Military Transport
—G. W. HALDEMAN, Civil Aeronautics Administration

Standardization of Design and Requirements for Commercial Transport Airplanes
—W. W. DAVIES, United Air Lines

Standardization of Design and Requirements for Military Transport Airplanes
—MAJOR-GEN. L. S. KUTER, Commanding General, Military Air Transport Service

(Sponsored by Air Transport Activity)

SATURDAY, Oct. 8

10:00 a.m.
A. L. KLEIN, Chairman

Auxiliary Gas Turbines for Pneumatic Power in Aircraft Applications
—H. J. WOOD and F. DALLENBACH, AiResearch Mfg. Co.

Aircraft Decelostat—A Device for Wheel Slide Protection
—A. J. BENT, Westinghouse Air Brake Co.

History, Characteristics, Service Experience and Future Prospects of ZK60 Magnesium Alloy Extrusion
—E. H. SCHUETTE, Dow Chemical Co.

(Sponsored by Aircraft Activity)

BANQUET and GRAND BALL

7:30 p.m. **SATURDAY, Oct. 8**

Grand Ballroom
The Biltmore Hotel

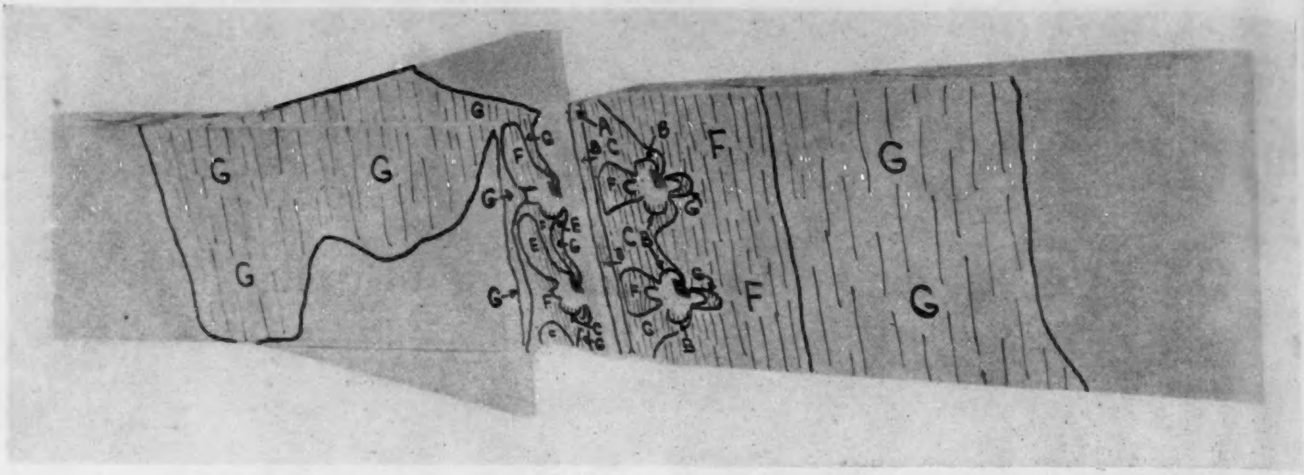


Fig. 1—Using Stresscoat, stress concentrations were obtained in this test specimen containing section changes, a fillet, and bolt holes. Minimum stress values in psi at the designated areas (which include bending stresses due to eccentricities) are: A—48,500; B—26,000; C—17,000; D—14,800; E—11,300; F—8,500; and G—5,700

Lack Data and Theory To Forecast Plane Life

Based on paper by

JOEL M. JACOBSON

Glenn L. Martin Co.

(This paper will be printed in full in SAE Quarterly Transactions.)

THE three missing links to accurate prediction of the fatigue life of aircraft structural components are:

1. Fatigue characteristics of the material in the form actually used in aircraft structures.

2. Anticipated load history of the part during its service life.

3. A reliable theory for estimating operating life when data in (1) and (2) above are available.

Because of the many individual tests necessary to define fatigue characteristics, the large variety of possible configurations, and the large number of aircraft materials, very little applicable data are available. Basic fatigue test data usually are obtained on smooth, round, or rectangular specimens. Aircraft structures are full of holes for bolts and rivets, radii at machined surfaces, and area changes which introduce stress concentrations of varying magnitude.

Stress concentrations in a test specimen containing section changes, a fillet, and bolt holes are shown in Fig. 1. This distribution was obtained by using Stresscoat, a brittle lacquer which will form fine cracks at known stress levels.

Both static and fatigue tests show that effect of stress concentrations is not as great as theoretical values would indicate. This generally is attributed to the ductility of engineering materials and their tendency to flow slightly at points where local stress exceeds the elastic limit; this sheds the load to some of the lower stressed areas. When the average stress approaches the ultimate strength of the materials, the peak strains will have passed the yield point and the material will have started to flow locally, so that the actual local stresses will be only slightly above the average.

Obviously stress concentration factors for fatigue loadings will vary with geometry, size, relation of bending to direct stress, stress level, and material characteristics. •One phase of fatigue research must be directed towards a solution of this problem. Much additional information is required. But most of all, some theoretical basis must be developed if we are to avoid collecting a great mass of unrelated and inconclusive test information.

To apply fatigue test data for the material to prediction of airplane life, accurate data must be available on loads occurring during actual service operation—both as to their magnitude and frequencies.

Since no two airplanes will have identical load histories, such information can only be obtained statistically over long periods of operation. Data on wings, tails, landing gears, fuselages, control systems, and other structural parts are needed. Only portion of these data on which a sufficient number of measurements to form a statistical basis now available is wing gust formation.

Life of a particular airplane part is controlled by its total load history. For example, with wings, the frequency and magnitude of landing stresses must be considered; for landing gears, retracting and flight stresses may result in repeated loads which, though low in magnitude, occur often enough to affect its life seriously. Other parts —such as engine mounts, propellers, and controls—have very special life histories and must be considered as individual problems.

For estimating life expectancy, the S-N curve for the material has been derived from individual tests to failure at a given series of load levels. But the aircraft structure is subjected to repeated stresses at many different load levels. Many studies have been made of the effect of stressing at one load level on the life at another load level without yielding any clearly proven method for life calculation.

Because of the complexities of calculation, lack of adequate data, and absence of a reliable theory for life prediction, the Martin Co. has pioneered the repeated load testing of complete airplane components. In most cases this has been done after service experience showed up a deficiency. Approach to the problem has been positive and direct.

Tests of the components are made using assumed loads and loading conditions until failure duplicating the service fracture. The parts then are modified until, under this loading condition, they give increased life sufficient to insure adequate service. This method has proved very satisfactory.

The number of factors and lack of both data and a definite theory make it impossible to more than make a reasonable guess as to life expectancy. But several important design factors should be stressed when fatigue is considered.

First, the serious effect of local stress concentrations cannot be overemphasized. Every effort should be made to reduce them by proper design at the start. Use of high-strength material is only safe when the "1 g" stress levels are low enough so that lack of a fatigue strength increase proportional to the static strength is not a problem.

In operation of airplanes, instructions must be issued to avoid turbulent conditions. If this is not possible, the

airplane should be slowed down to reduce the stresses due to gust. This procedure will be both safe and economical. (Paper "A Review of Problems in the Life Evaluation of Aircraft Structures," was presented at SAE National Aeronautic and Air Transport Meeting, New York, April 11, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Instruments Essential To Achieve Economies

Based on paper by

M. E. NUTTILA

Cities Service Oil Co.

TWIN economies of transportation are fuel economies and maintenance economies, and "know how" is required to achieve economical operation and maintenance.

Good instruments are most useful yardsticks to guard against over maintenance—such as fixing the wrong things, or fixing the right things but at the wrong time.

Cities Service Oil pioneered types of instruments to promote efficient and economical operation of motor vehicles by endeavoring to isolate mechanical troubles from fuel troubles.

Proper remedy depends on proper diagnosis, which in turn is made easier with proper equipment, when used by men who have been trained in fundamentals and have good judgment.

Items of heavy repair expenses, such as ring and rebore jobs, can be stretched out longer before a drop in power has reached a point of driver complaint by knowing the conditions inside an engine.

Unless the ring condition is known it is difficult to make decisions on necessity for repairs. After ring condition is known some correlation between test information and potential power is useful.

Published information on this point is scarce, but some believe that hp loss at peak power is not directly proportional to the drop in compression pressure, but rather the drop in peak approximates one-half the drop in compression pressure, where the latter is assumed at cranking speeds.

Assume a standard 10% power loss before overhaul. Then if all the items of minor expense are in good repair and if the power loss ratio mentioned above is substantially correct, the compression loss could be about 20% before a ring job was indicated.

If items of minor repair were not detected and put in order, and if they were responsible for half the power loss, then a ring job might be done much earlier than actually needed.

Among the more important instruments for economical fleet maintenance are:

1. Exhaust gas analyzer,
2. Compression leakage tester,
3. Top dead center finder,
4. Compression tester,
5. Vacuum gage,
6. Cam angle meter,
7. Distributor tester,
8. Spring tension scale,
9. Timing light,
10. Fuel level gage,
11. Fuel pump pressure tester, and
12. R.P.M. gage.

One of the most important "instruments" is the other trucks in the same fleet, particularly the identical vehicles. This permits ready comparisons.

Considerable improvement has been made in test equipment for engines during the past decade. There is general agreement, however, that in any complete series of tests the carburetor should be adjusted last because efficient carburetion depends on the mechanical and electrical condition of the engine. (Paper "Modern Engine Testing Equipment" was presented at the SAE National Transportation Meeting, Cleveland, March 30, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Manufacturing the Australian Holden

Excerpts from paper by

W. E. HILL

General Motors Overseas Operations

MANUFACTURE of the Holden car in Australia stemmed from a strong desire of that country to industrialize, despite the relative lack of industrial facilities and know-how required for such an enterprise.

General Motors entered the automobile industry in Australia in 1926, assembling cars and trucks. But it is one thing to assemble a car and quite another to manufacture one. Cars can be assembled in countries which may be entirely devoid of natural resources, primary and secondary industries, and with comparatively low availability of skilled labor. This is not true when a car is to be manufactured.

There are certain essential elements which a country must possess in reasonable degree if it hopes to manufacture economically such complicated machines as automobiles. I should like to mention a few of these essential elements because in doing so, it will

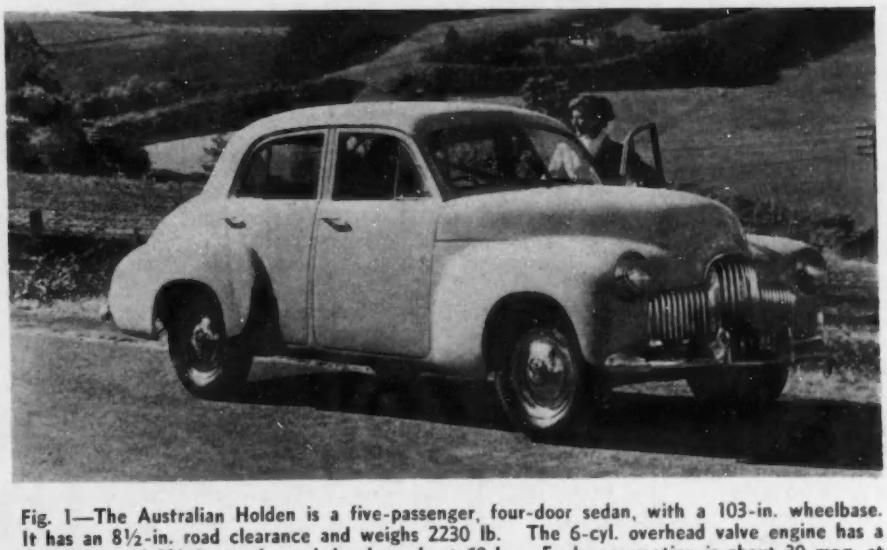


Fig. 1—The Australian Holden is a five-passenger, four-door sedan, with a 103-in. wheelbase. It has an 8½-in. road clearance and weighs 2230 lb. The 6-cyl. overhead valve engine has a 3-in. bore and 3⅛-in. stroke and develops about 60 hp. Fuel consumption is about 30 mpg. at 35 mph. The engine has good acceleration and the car has a top speed of more than 80 mph.

be possible also to point out some of the problems which we anticipated and which we have faced in producing the Holden car.

First of all, a country must have large markets and mass purchasing power to reap the economies of mass production. Australia, with its small population of 7½ million people, hardly measures up to this requirement.

The total market in Australia for cars and trucks of all makes approximates 80,000 to 100,000 vehicles a year, largely from American, Canadian and English sources, as compared for example to more than four million here in the United States.

The capacity of the manufacturing facilities which we have established in Australia contemplates the production of 20,000 cars and companion utilities annually, operating on a one-shift basis. Of course, the unit cost of overhead on a volume as small as this is considerably heavier than is the case here at home where vehicles are produced in much greater quantities. Consequently, we are unable to produce a car in Australia as cheaply as we would like. But even so, the Holden is priced lower than most of the imported cars with which it is in competition.

Growing Market

Despite the fact that Australia cannot at this time be regarded as a mass market, we anticipate an expanding absorption of motor vehicles in Australia because of its natural growth in population and its immigration which is being carried on at an increasing rate. Quite naturally, too, Australia has an eye to the possibilities of exporting this car some day in the future, particularly to such pound-sterling and other adjacent territories as New Zealand, South Africa, India and Indonesia.

Still another essential is an adequate number of secondary or supporting industries for converting these raw materials into semi-finished and finished products. It is in this area that we have had one of our toughest problems.

Such industries are limited in number. And in a country where motor cars have never been built before, it is understandable that there would be difficulty in obtaining, in the early stages, continuity in delivery of product in either the quantity or quality which would meet our rigid specifications. We have installed our own foundry for making gray-iron castings, but it has been difficult for us to obtain from local producers such items as malleable iron castings and certain forgings which measure up to the standards of quality required for original equipment car parts.

Another essential is a sufficient number of specialized industries for production of items such as ball and roller bearings, carburetors, starting motors, brake linings, wheels, and electrical equipment. In most cases, specialized industries of this kind have not as yet been fully developed in Australia, so that many of these items are among those which we import. (We are allowed to import original equipment equal to 10% of the established list price, or 5% by weight.)

We are able to obtain some bearings and certain electrical items locally. But while progress is being made in this field too, it will probably be very much to Australia's advantage to continue the importation of certain of these selected items, since the investment required to establish plants to manufacture them locally is out of proportion to the volume which the market could absorb. Consequently, such items will continue to be good import bargains for some time to come.

Yet another essential is an adequate system for the transportation of raw materials and heavy goods. In a country as large and sparsely settled as Australia, this presents a difficult problem, especially as Australia has no canals or inland waterways; in fact, she has been endowed by nature with no great rivers at all. Her largest river, the Murray, does not compare, for example, with our own Hudson; although it is quite long, it is shallow and navigable at only a few points.

All of Australia's major cities are located on the sea coast and depend largely for the movement of goods upon coastwise shipping, but distances are great and traffic correspondingly slow.

Rail transportation is badly handicapped by the fact that prior to the federation of the Australian States into the Commonwealth, each state was autonomous and installed its own railroads. Unfortunately, during that period, it was apparently impossible for the states to agree upon a track gage that would be common to the railroads in all states. Consequently, today the Commonwealth suffers from a situation which involves three different gages of track.

Gage Difference Costly

This condition requires the unloading and reloading of all passengers and freight at most state borders, necessarily slowing up traffic and adding considerably to freight costs.

One other essential is the need for experienced personnel and skilled labor. Australian workmen as a group have a relatively good education and are adept at learning new methods and processes. However, not having been accustomed to the type of precision manufacture required for this project, it was to be expected that the training of men to operate the highly complicated and specialized machines installed at our manufacturing plants would be a long job. But it has been made more difficult and costly by the very heavy labor turnover which is common to all basic industries in Australia since the war, due to manpower shortages.

I am afraid, too, despite the facility with which the individual workman masters the techniques of modern precision manufacture, that the inevitable breakage of tools and the wastage of materials which always attend the training of new men, to say nothing of the time consumed, will continue to be a serious problem and a heavy expense for some time to come.

When it was decided to build a car in Australia, our first step was to make a complete on-the-ground survey to determine what specifications were required in a car specifically tailored to meet Australian conditions.

This study covered a period of about a year and disclosed that the car should be somewhat smaller than the American Chevrolet, but larger than the smaller European and English cars; that it should have more road clearance than the average car to negotiate the rough roads in the back country; that it should have better hill-climbing performance in high gear than the lower horse power English cars; that it should be as dust-proof as possible for a country of high winds and dust; that it should be extremely economical in fuel consumption, since Australia imports all of its petroleum products which are heavily taxed and severely rationed; and that it had to be light in weight to gain the needed fuel economy, but extremely rugged to give it long life and to withstand wear and tear. Australians keep their cars over much longer periods than we do.

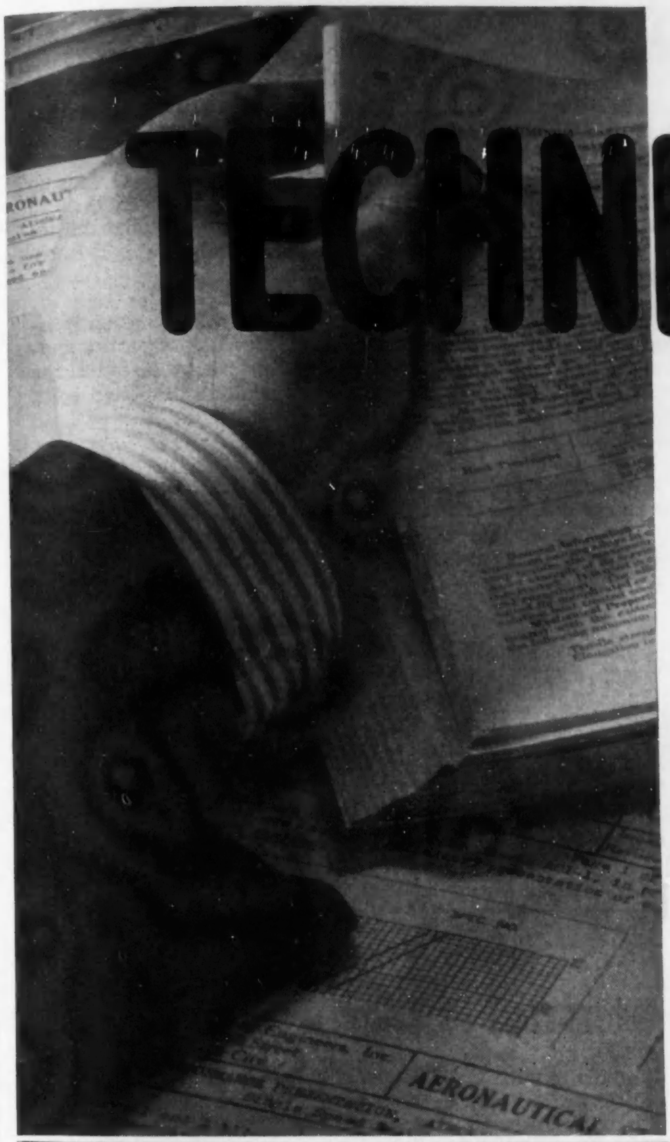
With these general specifications in hand, we turned to Detroit where the full cooperation, facilities, manpower, and technical know-how of General Motors Corporation were placed at our disposal. Specialists in motor car design, engineering, and styling were assigned to the project by the Corporation, and some 30 engineers and technicians from our Australian operations were brought to the United States to gain experience during development stages. After much work and study a car was designed to meet these specifications, and three prototype cars were built and thoroughly tested at the General Motors Proving Ground.

When the pilot models had proved satisfactory in this country they were taken to Australia together with the personnel. In the meantime, the manufacturing plants had been designed, the machinery purchased and shipped to Australia, so that the plant facilities were well under way when the pilot models arrived.

An 86-mile test course was laid out, including every type of road condition which a car might reasonably be called upon to meet, and the prototype cars were driven over this course day after day, under controlled operation. Three more pilot models were built in Austra-

Cont. on p. 84

TECHNICAL COMMITTEE PROGRESS



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Steel Shot Surpasses Iron For Blast Cleaning Parts

STEEL shot is better than iron for blast cleaning, N. S. Mosher, Chevrolet Motor Division, GMC. recently reported to the Shot Peening Division of the SAE Iron & Steel Technical Committee.

Mosher said that his company juggled various machines to compare the effectiveness of different kinds of shot. This investigation indicated that both cast steel and cut-wire shot are better than cast iron, malleable iron, and all other forms of iron shot. However, the relative merits of cast steel and cut wire are yet to be determined. (Advantages of cut-wire shot for peening are discussed in the article in the August, 1949, SAE Journal, pp. 44-51, "New Cut-Wire Shot Big Boon to Peening," by H. H. Miller.)

Another point Mosher's report brought out is that maintenance costs are 50% less for cast steel than for cast iron. One $12,000 machine with a fair maintenance record, running with iron shot, cost more than $4000 per year to maintain.

Difference between steel and iron shot lies in the amount of shot to produce a given number of tons or pieces of production. In response to a questionnaire sent by GMC to all of its plants, it was found that iron shot usage for blast cleaning varied from 50 to 350 tons of work per ton of shot.

According to Mosher, a check of these operations revealed that plants using 1 ton of shot for 100 tons of work or less had machines in bad conditions. Most of them were leaking and had considerable carry-over. With iron shot at $90 per ton, it was costing from $.90 to $1.80 per ton of work produced for shot alone, to say nothing of

the maintenance upkeep, continued Mosher.

Those plants that reported better than 200 tons of work to 1 ton of shot were not doing as good a cleaning job, but were getting away with it and inspection passed their work. Apparently degree of cleanliness achieved by blasting seems to be up to the individual plant, observed Mosher.

Average for doing a fair cleaning job seems to be about 150 tons of work to 1 ton of iron shot, with the standard machine set up to use 230 or 330 iron shot. On machines using larger shot, said Mosher, time for shot breakdown varies directly with increase in shot size.

He also noted that a screening sample taken from any standard wheel, throwing at 200 fps and using from 330 to 660 shot, will leave the bulk of the sample on the 0.023 and 0.033-in. screens, provided no new iron shot has been added to the machine for 3 hr before the sample was taken. The larger the shot, the more grit on the screens and the less round shot. To Mosher this seems to prove that iron shot will take only a light impact because of the nature of the material.

Technishorts . . . .

FAN STANDARDS: Four standards for engine fan hubs are being planned by the Fan Mounting Flanges Subcommittee, of the SAE Engine Committee, to reduce the large variety presently specified. The four standards proposed will cover automotive fans up to 36 in. in diameter. They are: (1) fans up to 19 in. in diameter; (2) those from 20 to 24 in.; (3) those from 25 to 28 in.; and (4) those from 29 to 36 in. Among the items the Subcommittee plans to specify are factors such as pilot diameter, number of bolt holes, bolt hole diameter, and diameter of bolt hole circles.

UTILITY PARTS: Air Force-Navy Aeronautical Bulletin 343a, recently issued, provides for recognition for the industry-generated utility parts standards for airplane engines and propellers, developed by SAE. Listed in the Bulletin are 108 of these standards, covering parts such as hex head bolts, steel dowel pins, high-temperature rivets, O-ring seals, flat fillister head screws, and steel washers.

CHEMISTRY CHANGED: Chemical compositions of SAE 5132 and 5147 steels recently were changed so that the hardenability of these two steels will be substantially comparable with their H-band steel counterparts, 5132H and 5147H. The changes are as follows:

	5132		5147	
	Old	New	Old	New
Carbon	0.30/0.35	0.30/0.35	0.45/0.52	0.45/0.52
Manganese	0.60/0.80	0.60/0.80	0.75/1.00	0.70/0.95
Silicon	0.20/0.35	0.20/0.35	0.20/0.35	0.20/0.35
Chromium	0.80/1.05	0.75/1.00	0.90/1.20	0.85/1.15

SAE Group Plans Body Paper Specs

PRELIMINARY studies indicate the feasibility of SAE Specifications for paper and cardboard body materials, the Fibreboard Standards Subcommittee, of the SAE Body Engineering Committee, recently agreed.

Possibility of preparing first-time standards for such paper products grew out of an investigation started by the Subcommittee nearly two years ago. Purpose was to determine whether standard methods for testing papers and cardboard for automotive use could be developed.

Samples of fibreboard were tested by Subcommittee members for properties such as dimensional stability and water absorption. Substantial agreement between results of several independently conducted tests pointed up the possibility of developing standard test procedures. The Fibreboard Standards Subcommittee already has started this job.

Members of the group are: J. W. Greig, Woodall Industries, Inc., chairman; George Hanson, Fisher Body Division, GMC; C. H. R. Johnson, Consolidated Paper Co.; Dr. J. S. Laird, Ford Motor Co.; B. A. Luce, Chrysler Corp.; E. Orth, Fabricon Products, Inc.; and F. M. Murphy, Simplex Paper Corp.

You'll Be Interested to Know. . . .

SAE IS COOPERATING with the Engineers Joint Council in helping to provide the National Military Establishment with source material for a who's who in engineering research, development, and other scientific operations. . . . The source file of key engineering personnel thus obtained is designed to help the NME to solve a variety of technical personnel problems. . . . SAE members, along with members of other technical societies, will soon get a 4-page questionnaire, returns from which will be collected by the American Society of Mechanical Engineers and turned over to the Office of Naval Research of the NME for classification.

CALIFORNIA STATE POLYTECHNIC COLLEGE is the site of SAE's newest Student Branch. Started as an informal SAE student club in February, 1948, it now has 86 SAE Enrolled Students; was granted a Student Branch Charter by Council in June. The new Student Branch is located at San Luis Obispo, Calif. Its chairman is Alvin Gerenbein and its faculty adviser, Prof. Thomas Hardgrove.

UNITED STATES' DELEGATION to the United Nations Conference on Road and Motor Transport, which convened at Geneva, Switzerland on Aug. 23, had three SAE members in its personnel. Heading the delegation was H. H. Kelly, assistant director, Office of Transport and Communications, Department of State. The other SAE members were SAE Past-President J. H. Hunt, General Motors Corp., who represented the Automobile Manufacturers Association, and Edward G. Sparrow, who represented the American Automobile Association and the American Touring Alliance.

Atlanta Group—Sept. 19

Town House Tea Room, 110 Forsyth St., N.W., Atlanta, Ga.; dinner 7:00 p.m. Program 8:00 p.m. Engine Design for Past, Present and Future Fuels—Max M. Roensch, research coordinator, Ethyl Corp., Ferndale, Mich.

Baltimore—Sept. 8

Annapolis, Md.; summer cruise. Inspection trip through U. S. Naval Engineering Experiment Station. (Leave Fort McHenry, Baltimore 10:00 a.m. aboard Navy LCT and return to Baltimore about 6:30 p.m.).

British Columbia—Sept. 26

My Friend, the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., and president, SAE.

Chicago—Sept. 19 and Sept. 23

Sept. 19—South Bend. First meeting for current season.
Sept. 23—Sixth annual Play Day.

Cleveland—Sept. 12

Elks Club, 107th and Carnegie; dinner 6:30 p.m. Lubrication and Friction—Ed Bisson, NACA Laboratory.

Northern California—Sept. 29

Hotel Claremont, Berkeley, Calif.; dinner 6:30 p.m. My Friend, the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., and president, SAE. An informal reception for Sparrow and past-chairmen will be held prior to the meeting.

Fresno Division—Sept. 12 and Sept. 30

Sept. 12—The Desert Inn. Aviation Meeting. Time, speaker and subject to be announced.
Sept. 30—Location and time to be announced. My Friend, the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., and president, SAE.

Northwest—Sept. 23

My Friend, the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., and president SAE.

Oregon—Sept. 27

My Friend, the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., and president SAE.

St. Louis—Sept. 13

McDonnell Aircraft Corp., St. Louis, Mo.; 2:00 to 3:30 p.m. Tour and general inspection of plant, also viewing movies of projects that have recently been developed and completed by McDonnell Aircraft Corp.

Salt Lake Group—Sept. 20

My Friend, the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., and president, SAE.

San Diego—Oct. 3

Marine Room, San Diego Hotel, 339 W. Broadway; social hour 6:00 p.m.; dinner 6:30 p.m. My Friend, the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., and president, SAE.

Spokane-Intermountain—Sept. 22

Round Up Room, Hotel Desert; dinner 7:00 p.m. My Friend, the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., and president, SAE.

Twin City—Sept. 12

The Normandy Room, Hotel Normandy, 405 S. 8th St., Minneapolis, Minn.; dinner 6:30 p.m. My Friend, the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., and president, SAE.

NATIONAL MEETINGS

MEETING	DATE	HOTEL
TRACTOR	Sept. 13-15	Schroeder, Milwaukee, Wis.
AERONAUTIC and Aircraft Engineering Display	Oct. 5-8	Biltmore, Los Angeles
DIESEL ENGINE	Nov. 1-2	Chase, St. Louis, Mo.
FUELS & LUBRICANTS	Nov. 3-4	Chase, St. Louis, Mo.
ANNUAL MEETING and Engineering Display	Jan. 9-13, 1950	Book-Cadillac, Detroit
PASSENGER CAR, BODY, and PRODUCTION	March 14-16	Book-Cadillac, Detroit
AERONAUTIC and Aircraft Engineering Display	April 17-19	Statler, New York

About

DON R. BERLIN has been made executive vice-president of McDonnell Aircraft Corp. in St. Louis, Mo. He had been vice-president in charge of engineering and contracts.

E. V. RIPPINGILLE, JR., has been appointed president and general manager of a new General Motors subsidiary. General Motors Diesel, Ltd., will begin construction immediately of a plant at London, Ont., Canada, for the manufacture of Diesel-electric locomotives in Canada. Rippingille was manager of plant no. 2 of General Motors Electro-Motive Division, near Chicago, until Aug. 1.

R. R. LaMOTTE has been named chief engineer for Aeroproducts Division, General Motors Corp., Dayton, Ohio. He joined Aeroproducts as chief metallurgist in 1941 and became manager of product engineering in 1946. In March, 1947 he was promoted to assistant chief engineer and has been acting chief engineer since January of this year.

JAMES H. DAVIDSON, JR., has joined the Clinton Machine Co., Clinton, Mich., as sales and service engineer. He was previously in the Field Product Engineering Department of Timken-Detroit Axle Co.

GERALD W. HOGAN, JR., is now sales engineer at the Camden, N. J. office of Warren Webster & Co.

GEORGE A. LUNDIN, JR., has become junior experimental engineer for the LeRoi Co., West Allis, Wis.

HERBERT D. TUCKER recently became senior detail draftsman for the Fisher Body Corp. in Detroit.

FREDERICK CARL FOSHAG is now research engineer A, test and facilities section, Marquardt Aircraft Co., Subsidiary of General Tire & Rubber Co. of Calif., Van Nuys, Calif. He had been connected with Packard Motor Car Co., Toledo, Ohio.

ANTHONY TODISCO is now an aerodynamist for Chase Aircraft Co. in West Trenton, N. J.

DON R. MITCHELL, president of Ionia Manufacturing Co., Ionia, Mich., announces the appointment of **HARRY WESTLAND** as general sales manager of the Seating Division.

RALPH M. REEL, technical service manager of the Dayton Rubber Export Co., Dayton, Ohio has just returned from a three-month business trip through continental Europe. He spent this time in Europe to contact and service various European companies to whom Dayton Rubber renders technical assistance. Reel says that economic conditions in Europe have improved considerably as compared with last year.

DR. WALTER E. JOMINY, staff engineer, Chrysler Corp., will be the next vice-president of the American Society for Metals. He will take office at the ASM annual meeting on Oct. 19 at the Hotel Statler in Cleveland, Ohio.

G. L. TRENTHAM, JR. has recently become an automotive engineer at the Wofford Oil Co. of Georgia in Atlanta. He was previously affiliated with the Sinclair Refining Co., same city.

TAYLOR

FLORA

HARTMAN

W. H. TAYLOR has been named assistant to the vice-president of Tinnerman Products, Inc. He joined the organization in 1945 and was named director of engineering a year ago. **L. H. FLORA** has been named chief engineer, having previously served as chief development engineer. He will direct all phases of product, development and research engineering. **R. A. HARTMAN** is now manager of field engineering and will render special technical service to Tinnerman customers

Members

MACY O. TEETOR, a past SAE vice-president and retired vice-president of engineering, Perfect Circle Co., has been in New Orleans for the past three years inventing what he feels like inventing, developing unorthodox ideas in a multitude of lines. Recently he was the subject of a feature story in the "New Orleans Item", titled "Executive Turns Inventor and Likes It." Noted among his inventions were: an improved coat hanger that enables a man to hang up his clothes in the sequence he takes them off—coat first then trousers—instead of just backwards as he does now; a magnetic cabinet catch which he plans to make and sell under the trade-name "Magnecatch"; and "Bankeeping", an improved system of check writing that also provides a means for accumulating budget and tax information . . . and he continues to write music. His latest: "When You Live Down South."

HERBERT K. SACHS is a mechanical engineer (designing) at the American Car & Foundry Co. in Berwick, Pa.

R. G. SHANKLIN has been appointed manager of petroleum products, retail merchandising department, at Socony-Vacuum Oil Co., Inc. He was formerly division marketing assistant for motor oils and specialties in the company's Albany, N. Y., division.

GEORGE W. BRADY has been promoted to director of engineering of the Propeller Division of Curtiss-Wright Corp. and will have under his supervision the engineering development of the new rocket powerplants as well as propellers. He has been chief engineer of the Propeller Division since 1938. Brady is the most recent winner of the Sylvanus Reed Award for his contributions to the successful development of the revolutionary reversible propeller which makes possible shorter landing runs for large aircraft. It is one of the principal safety factors on modern airplanes.

JAMES D. MOONEY, recently resigned as president, Willys-Overland Motors, has been named to the board of directors of Eversharp, Inc., Chicago.

PHILIP H. SMITH has taken the position of sales representative for the Johnson Rubber Co. in their new Detroit office. He was formerly district engineer for the General Tire & Rubber Co.

WILLIAM C. KOSSACK is a safety engineer for the Employers Mutual of Wisconsin in Wausau, Wis.

GEORGE SONNEMANN is now assistant professor of aeronautical engineering at the Drexel Institute of Technology, Philadelphia, Pa. He was previously instructor in engineering mechanics at the University of Detroit.

WILLIAM R. HIGGINS is a junior engineer for the American Locomotive Co. in Schenectady, N. Y.

BOB E. MARTEL is a junior engineer for the Sohio Pipe Line Co. in St. Louis, Mo.

RICHARD S. HUXTABLE, executive vice-president of Fawick Airflex Co., Cleveland, and a past-chairman of the SAE Cleveland Section, has been elected a director of the Cleveland Athletic Club for a three-year term. Huxtable is vice-chairman of Fenn College of that city.

CHARLES F. KETTERING, (left) and **WILLIAM A. CHRYST,** retired Delco chief engineer, unpack the first electric automotive self-starter as it arrived at Dayton, Ohio, for the 40th anniversary of Dayton Engineering Laboratories Co. (Delco) on July 22. The starter, which was introduced on the 1912 Cadillac, was produced in the E. A. Deeds' Barn Machine Shop, where Kettering and Deeds founded Delco. Chryst was Delco's first chief engineer who worked on the project. The starter was shipped from Chicago's Museum of Science & Industry.


MacPHERSON


OSWALD

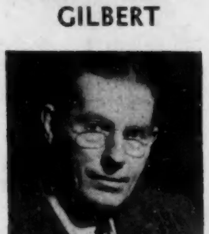

TALLBERG


ROEDER


CURRIER


GILBERT


FREHSE


BELTZ


GREBE

Youngren Announces Ford Engineering Changes

HAROLD T. YOUNGREN, vice-president—engineering, Ford Motor Co., has announced several shifts in the engineering staff to meet the company's increased engineering program. **EARLE S. MAC PHERSON,** formerly executive engineer on design and development, has been named chief engineer on all company products under Youngren. **JOHN OSWALD** is executive engineer for styling and body engineering. **V. Y. TALLBERG,** administrative engineer, has been given increased responsibilities and **DALE ROEDER,** who for many years has been head of commercial vehicle engineering, has been named executive engineer for this group. **H. S. CURRIER** heads Ford passenger car engineering, while **H. H. GILBERT** heads Lincoln-Mercury passenger car engineering. Other department heads include: **ROBERT F. KOHR,** research engineer; **A. W. FREHSE,** test engineer; **L. L. BELTZ,** electrical engineer; and **H. GREBE,** body engineer.

JERRY GENE TOMLINSON is a laboratory technician for the Allison Division of General Motors Corp., Indianapolis, Ind.

JOSEPH GESCHELIN, Detroit Editor, Chilton Publications, and vice-chairman of the SAE National Production Activity Committee, was featured in a 15-minute interview on Station WJR, Detroit, on Aug. 13. The interview was based upon a series of articles in the publication Motor Age, answering criticism of motor car design which appeared in recent months in several national magazines.

RAYMOND T. PARR is now a junior industrial engineer in the Standards Department of the E. F. Hauserman Co., in Cleveland.

ERVIN N. HATCH, senior automotive mechanical engineer, New York City Transit System, was at Lutterworth, England from Aug. 14 to Sept. 2 taking a specialized course of lectures and plant visits at the School of Gas Turbine Technology, operated by Power Jets Research & Development, Ltd. This is the 5th International Course given by the School.

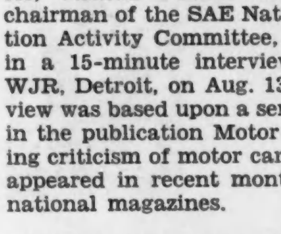
JAMES L. DOOLEY has become chief engineer for the Rhodes Lewis Co. in Los Angeles, Calif. He was previously mechanical engineering consultant for North American Aviation-Aerophysics Laboratory and the Rhodes Lewis Co.

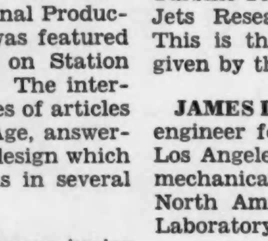
EDWARD RAY SEARBY is an engineer at the Cummins Engine Co., Columbus, Ind.

DON HUNTER is now employed by the DeHavilland Aircraft Co., Ltd., Hatfield, Herts, England, in the capacity of aircraft draftsman.

CLAIR M. CRISPEN is field engineer at Chrysler Airtemp Corp., Dayton, Ohio.

FRANCIS J. BOROWSKY has been named junior vice-president in charge of sales for the George K. Garrett Co. of Philadelphia. He was formerly sales manager of Garrett's for many years, having been with the company for 12 years. Borowsky has been instrumental in many of the developments of the company and directly responsible for the invention of new type of molding clips being used today, as well as other small parts.


PEARSON


MARTIN

C. C. PEARSON, who resigned May 31 as vice-president of Curtiss-Wright Corp., was elected president, general manager, and a director of Glenn L. Martin Co., Baltimore. He succeeds **GLENN L. MARTIN,** who assumed the new position of chairman of the board. Pearson entered the industry with Douglas Aircraft Co., Inc., in 1930 and during the war was manager of that company's plant at Oklahoma City where more than 5000 multi-engine cargo airplanes were built for the military services. He joined Curtiss-Wright Jan. 1, 1947. Martin organized the pioneer aircraft company 40 years ago soon after he had designed, built and successfully flown a biplane.

HOWARD E. BLOOD has been elevated to chairman of the board of Norge Division of Borg-Warner Corp., while still retaining the presidency of Detroit Gear Division.

CLESSON W. GENSON recently became resident transmission engineer acting directly as assistant chief engineer for the Gear & Forge Division of the Clark Equipment Co., Jackson, Mich. Prior to this post he was assistant chief engineer for the Oliver Corp. in Cleveland, Ohio. Genson was a panel leader at the 1948 SAE Production Meeting in Cleveland.

JAMES T. COLIZ is now employed by the United States Instrument Corp., Summit, N. J., as a development engineer.

JAMES M. SHARKEY has become sales representative in New York State for the Perley A. Thomas Car Works, High Point, N. C. Formerly he was sales representative for the Truck Equipment Co., Norwalk, Conn.

WALTER R. WESTPHAL, now research and test engineer at Ford International Co., Dearborn, Mich., had been director of engineering, Cushman Motors Works, Lincoln, Nebr.

DWIGHT R. CRAIG recently became mechanical and electrical engineer for the Cooper-Bessemer Corp. in Mount Vernon, Ohio.

JOHN J. NARGI recently became project engineer for the BG Corp. in New York City. He was previously a research engineer for North American Aviation, Inc. in Los Angeles.

PHILLIP S. MYERS, assistant professor of mechanical engineering at the University of Wisconsin, has been selected to receive the National Pi Tau Sigma Gold Medal Award for 1949 for outstanding achievement in mechanical engineering. The medal is awarded annually by this honorary mechanical engineering fraternity.

H. W. OVERMAN has announced his resignation as president of the Unit Mfg. Co. in Columbus, Ohio. He is considering returning to the brake lining industry in a sales engineering capacity.

MICHAEL T. GACIOCH is an engineering draftsman for the Watervliet Ordnance Arsenal in Watervliet, N. Y.

LYMAN A. WINE has been appointed assistant to the president of the Electric Auto-Lite Co. in Toledo, Ohio. This is a newly created responsibility in the company and will concern both organization and customer contact duties. He will have offices in Detroit, Toledo, and Cincinnati. Since joining Auto-Lite in 1942, Wine has been sales manager of the Lamp Division at Cincinnati.

EDWARD D. ALVORD, JR., is a junior engineer for the Standard Oil Co. (Ohio), in Cleveland.

HARRY H. TAKATA recently became senior draftsman at North West Airlines, Inc., St. Paul, Minn.

RALPH H. LONG, JR. is associate professor in mechanical engineering at the University of Maryland.

GERALD L. WOOD recently became a junior mechanical engineer for the Shell Oil Co., Inc. in San Francisco.

GEORGE MATTHEWS is now associated with the Midland Steel Products Co. as engineer in charge of frame design. He will have headquarters in the Detroit plant, working in conjunction with the Engineering Department in Cleveland as well. Since the war he was engaged by Studebaker in a consulting capacity in connection with their design of all postwar models.

EDMUND C. SULZMAN, sales manager, Wright Aeronautical Corp., engine division of Curtiss-Wright Corp., has been assigned the additional responsibility of directing the company's service activities. He now directs the sales, service, contract, license, spare parts, and field engineering programs for Wright.

EDWIN D. SCOTT has joined Peninsular Metal Products Corp. as chief engineer. Scott was one of the first five technicians assigned by the late Edsel Ford to the B-24 bomber project; and was closely associated with all its subsequent developments, its Air Force and War Production Board contacts.

H. McKINLEY CONWAY, JR., has been appointed the first director of the Southern Association of Science and Industry, a regional non-profit, non-political organization devoted to promotion of industrial research as a solution to Southern economic problems.

W. E. LYON has been promoted to tire development manager at the Firestone Tire & Rubber Co. He joined the Firestone organization's 1929 college training class following his graduation from Cornell University where he received his engineering degree. After 11 years of varied experience in the tire engineering department, he was named its manager in 1940, the position he has held until now. He is past vice-chairman of the SAE Akron-Canton district.

FRANK A. KIMMONS has been appointed purchasing representative in Miami for Pan American-Grace Airways, Inc. (Panagra). Formerly service analysis engineer for Panagra with office in Lima, Peru, he joined the company in 1946 as director of maintenance training.

HERBERT L. SCHNELL recently became purchasing agent at the General Electric Co. in Schenectady, N. Y. He had been manufacturing policy consultant for the company.

CHARLES R. OVERLY is now an engineer in the Production Department of the Humble Oil & Refining Co. in Houston, Texas.

ROBERT W. O'HARA has become detail draftsman for the Westinghouse Electric Corp., Sunnyvale, Calif.

LEWIS DILLWYN ECKARD, JR., is a junior engineer for the Boeing Airplane Co. in Seattle, Wash.

OBITUARIES

AUSTIN M. WOLF

Austin M. Wolf, one of the most loyal and hard-working members of the Society, died Aug. 22 in his home in Plainfield, N. J., following several months of illness. He was 58 years old.

An outstanding authority on automotive vehicle engineering, he had collected one of the most extensive libraries extant of books, drawings, and descriptions of passenger cars of the world. His annual descriptions of new models kept his fellow members informed in the SAE Journal for a number of years. This project had consumed much of his spare time.

Wolf began his career as draftsman for the Interboro Rapid Transit Co., New York City, had served as chief engineer for several motor vehicle concerns, and in 1928 embarked on a career as consulting engineer. Just prior to World War II he was appointed director of standards of the Division of Standards and Purchase of the State of New York. He served as engineering consultant to the Development Branch of the Army Ordnance Department during the recent war.

Soon after joining the Society in 1911 he became active in the Metropolitan Section, was elected secretary for the 1918-19 term, and served as chairman in 1920-21 and again in 1930-31. He was SAE Councilor during the 1935-36 and 1940-41 terms, and was SAE vice-president representing the Transportation & Maintenance Engineering Activity during 1943. He was one of the founders of the Mohawk-Hudson Group of the Society and was its perennial meetings chairman.

One of his most important services to the Society was as member and later chairman of the Membership Grading Committee for many years. He was active in local and national membership work and served as national membership chairman in 1940. He also found time to serve on numerous technical committees of the Society, including the Research Committee, chairmanship of the Highways Research Committee, lubricants subcommittee, motor truck rating committee and for several years SAE alternate representative on the Mechanical Standards Committee of the American Standards Association. He served on the ASA Standards Council.

Wolf's helpfulness to young and veteran engineers alike had become proverbial. His authorship on automotive engineering subjects was extensive. For nearly a quarter of a century he spent much of the summers in his country home in Rhode Island where he did a great deal of work on his historical collection.

EDWARD COVERLY NEWCOMB

Edward C. Newcomb, who was elected to SAE membership 37 years ago, died July 25 in a Boston hospital. He was 77.

After an unusually fruitful career in automotive and electrical engineering he returned a number of years ago to his birthplace, Scituate, Mass., and Sarasota, Fla., where he continued his studies and research work.

His engineering work began with Holtzer-Cabot Electric Co. in Brookline, and he was successively with B. F. Sturtevant Co., consulting engineer for the American Locomotive Co., headed his own carburetor development enterprise, was associated with Past-President Henry M. Crane with the Simplex Auto Co., was an early member of the National Advisory Committee for Aeronautics, and consultant to the Studebaker Corp.

Important among his successful research and development work was advancing knowledge about the two cycle diesel engine, including contributions to proper balancing of engines. He found time to improve oil burning equipment and electric motors and generators as well as carburetors and other automotive devices.

While with Holtzer-Cabot he designed and laid out the first automobile built in Massachusetts. He began this project when only 19.

Always kindly and unassuming despite his numerous achievements, Newcomb left rich memories of friendship and sympathetic understanding with the many who knew him during his long engineering career.

THOMAS P. ARCHER

Thomas P. Archer, vice-president and a director of General Motors Corp., died in Detroit on Aug. 10. He had been inactive for more than a year because of illness.

In his youth, while a newspaper reporter in Kentucky, Ohio, and Indiana, Archer studied mechanical engineering, and business and factory management in night school, and joined GM's Turnstedt Division following his service as a ground officer in the U. S. Naval Air Service during World War 1.

By 1925 he had been promoted to general manager of that division, and four years later was named general manager of the corporation's Fisher Body Division.

He was elected a vice-president in 1943 and put in charge of the manufacturing and real estate staffs of GM. Five years ago he succeeded Edward F. Fisher as general manager of Fisher Body Division.

Archer held a number of patents on automotive devices. He was elected a member of SAE in 1923.

JOHN P. HILANDS

John P. Hilands, who devoted practically his entire career to the tubing business, died suddenly on June 18. He was 65 years old.

General manager of sales for the Tube Reducing Corp. in Wallington, N. J., he had been connected with that company since 1935. His other associations include the Shelby Tube Co., National Tube Co., Peter A. Frasse & Co., and the Ohio Seamless Tube Co.

MARSHALL H. JONES

Marshall H. Jones, engineering and maintenance manager for Chicago and Southern Airlines, Memphis, was killed while on Navy Reserve duty June 13, when a transport crashed into mountainous terrain near Santa Monica, Calif. He was 31.

Commissioned an ensign in 1942, he was assigned to engine work at the Naval Air Technical Training Center, Millington, Tenn. He then directed line maintenance and was assigned to the Navy Training Command, Chicago, in 1944. He was released from active service with a commission as lieutenant (sg).

Jones joined Chicago and Southern in 1946 as assistant superintendent of engineering, and was named engineering and maintenance manager in 1947.

When the California accident occurred he was on active training duty with Navy Squadron VR 67 as engineering officer of that command.

He graduated from Memphis State College in 1939, and joined the Society two years ago.

The eyes of Texas Section are upon Russell F. Sanders as he describes testing of Chevrolet parts and completed vehicles

Texas Section Meets in New Servicenter

• Texas Section
J. T. Wade, Chairman

July 29—Felix Doran, Jr. and Felix Doran III played hosts to members and guests at a buffet dinner and meeting in the new Doran Chevrolet Servicenter in Dallas.

Russell F. Sanders described testing of Chevrolet parts and completed vehicles. Sanders is assistant to the experimental engineer of Chevrolet Motor Division of GMC.

The Dorans have invited the section to meet in their new building any time. They and their employees demonstrated their shop equipment to the SAE audience.

Emergency Techniques Used to Handle Cargo

• Hawaii Section
Rene Guillou, Field Editor

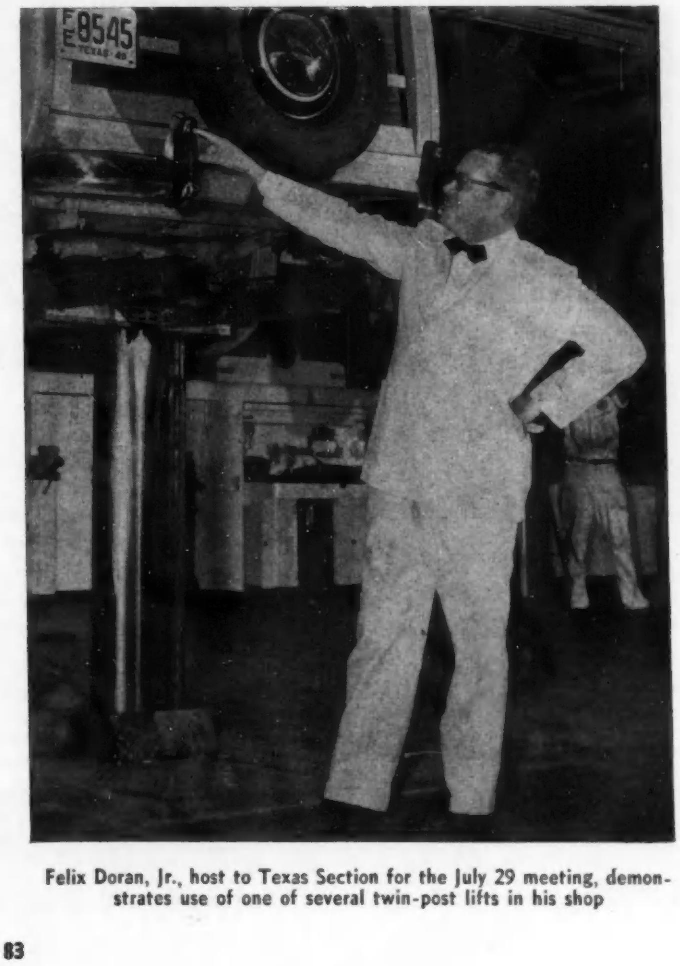
July 18—Emergency handling of the cargo tied up in the longshoremen's strike is presenting plenty of technical problems, **Robert Richardson** showed.

He explained that the United States Marshal in Honolulu has recently been ordered by the Federal Court to seize and unload certain cargo from strike-bound vessels. Neither power from the ship's boilers nor men familiar with the usual cargo-handling equipment have been available, and extreme care has been necessary to avoid accidents.

In some cases barge cranes, or shore cranes on the dock, have been used. This equipment, due to slow hoisting and swinging, has been able to handle cargo at only about half the rate usual for the ship's winches.

Where the ship is provided with electric winches, these may be operated with power wired from a diesel-electric dredge alongside or from a diesel-electric locomotive on the dock.

Efforts to operate steam winches on the ship with steam piped from a steam locomotive on the dock have been less satisfactory.



Felix Doran, Jr., host to Texas Section for the July 29 meeting, demonstrates use of one of several twin-post lifts in his shop

Northrop Aeronautical Institute

It takes a tremendous amount of work to develop an airplane like the B-45, Carl J. Hansen convinced this student branch at the July 13 meeting.

He revealed that the B-45 project required over 2,000,000 sq ft of blueprint paper and over 1,263,000 man-hours in the engineering department alone. Of this time, 45% was drafting time. Between 400 and 500 engineers worked on the B-45.

In comparing the B-45 with the B-25, Hansen said that although the B-45 is only twice as large as the B-25, the B-45 carries three times the bomb load at a much higher speed.

The B-45, which appeared on the drawing board in November 1943, was test flown for the first time in March 1947. The airplane was designed for high speed, maximum range, and ease of tactical operation. It has 22 self-sealing fuel cells. Its bomb bay takes up 33% of the overall fuselage length.

The forward crew compartment is pressurized. A liquid-fuel rocket system aids take-off under extreme conditions.

Hansen is assistant chief engineer of North American Aviation, Inc.

Australian Holden

Cont. from p. 74

lia and subjected to the same rigid tests.

In this type of controlled driving, each mile is equivalent to about four miles of ordinary driving. From time to time the cars were taken down, the parts inspected, and the inevitable specification changes made as actual usage dictated.

The new car, in Fig. 1, was shown to the public of Australia in November and its reception exceeded our fondest expectations. But, of course, only time will tell how completely sucessful our venture will be. (Paper "Manufacturing an Automobile in Australia," was presented at SAE Summer Meeting, French Lick, June 9, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Study Simple Controls For Personal Aircraft

Based on paper by

JAMES M. WICKHAM

Boeing Airplane Co.

INCORPORATING flaps and spoilers into a two-control system for personal airplanes gives promise of low landing speed, good glide control, and simple operation. While flight testing such a system verified its feasibility, it also points up need for further development aimed at eliminating the ground effect problem.

Basically the simplified system combines the airplane's flying functions in two flight controls—a steering wheel and brake pedal—and a throttle. The throttle is the hand type. The steering wheel has fore and aft motion to control the lift coefficient. Adding spoiler control to the brake pedal eliminates a separate spoiler control.

Spoilers make available enough glide control to permit a high approach without danger of overshooting. With spoilers controlled by the brake pedal, the pilot merely pushes the pedal if he wishes to steepen his glide. This is a natural action, similar to brake operation on the ground. Wheel brake application in the air does no harm; and lift-reducing action of the spoilers on the ground aids wheel brakes in getting traction at speeds just under landing speed.

Spoilers also provide wind stability when the airplane is parked with the brakes on. They are a potentially powerful control, particularly useful on a clean airplane, less useful on a dirty or heavily-flapped airplane.

Thought was given to eliminating the elevators and using the flaps as the only lift control. This requires further study since the elevators are the most fundamental control on the airplane.

Tests with this system on a Cessna Ercoupe revealed that the airplane was capable of ordinary flight control using only flaps, but could not make satisfactory landings without the elevators. This was due in part to the ground effect and the particular configuration and center of gravity of the test airplane.

While completion of flight testing found the simplified control system far from developed, much useful information had been uncovered. Most serious problem was the strong increase in stability near the ground together with normal increased stability of a high-wing airplane at low speed. This stability increase made the pilot run out of trim control during the landing flare.

Any further work on the system should focus on minimizing the ground effect problem. This calls for design and wind-tunnel testing of a model with a configuration suited to the pro-

posed simplified control system. Flight development would call for a new experimental airplane. (Paper "Research in Simplified Control," was presented at SAE Wichita Section, Jan. 20, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members. 50¢ to nonmembers.)

Tells How To Clean Automotive Equipment

Based on paper by

VALENTINE GEPHART

Valentine Co., Inc.

FROM a cleaning standpoint automotive equipment falls into five groups: (1) ferrous parts, (2) nonferrous alloy parts, (3) car exterior, (4) truck exteriors including chassis and running gear, and (5) garage floors and driveways.

The most efficient and by far the safest way of cleaning engine blocks and other ferrous parts is in hot alkaline degreasing tanks. The blocks and parts are submerged in a hot cleaning solution in these tanks. The solution consists of alkaline salts, compounded with powerful emulsifiers, wetting agents, and inhibitors to protect the bearings and other nonferrous parts.

First consideration in this process is selection of a tank of proper size which can be economically heated, and which is sufficiently insulated to minimize thermal losses. It should be equipped with an efficient air agitator. If electrical, the heating elements should be equipped with indicator lights and controlled by separate switches or a thermostatic circuit breaker.

The solution should be made up of a compound built to meet the particular raw water available in the locality in which it is to be used. Since water comprises about 95% of the solution, the impurities in the water are an important factor. Rapid scale formation on the heat exchange surfaces produced by the water impurities or an incorrect compound will reduce efficiency of the operation and materially increase the cost.

For this reason it is imperative that when formulating a compound for this purpose, careful consideration be given to emulsifying action, solvent powers, colloidal activity, saponifying values and wetting action for free rinsing, as well as water conditioning.

For cleaning aluminum, magnesium, and other nonferrous parts, those in the second category, inhibited alkaline cleaners can be used in a hot alkaline degreasing tank, like the type used for ferrous parts.

The cleaning material should be compounded with one of the new wetting agents and with an emulsifier, as well as with the proper water conditioning chemicals for the water to be used. For small parts, such as carburetors and fuel pumps, one of the small 5-gal containers of a solvent degreaser, which can be used over and over, seems most economical and satisfactory, especially for small shops.

In washing cars, the third type of cleaning job, the compound should have a pH reading of not less than 7.4 to 7.9, when made up in about a 1% solution in distilled water at 60 F. This factor eliminates many of the available synthetic detergents. Free rinsing is so important that wetting agents only 30 to 40% active were eliminated in our work.

While this costs a little more, the results are well worth it. It now takes only about 2¢ worth of these modern concentrated compounds to wash a car and leave it with a waxlike finish without wiping or chamoising. This saves a tremendous amount of labor.

Exterior washing of trucks and buses, the next cleaning category, is facilitated by the polysaccharides, particularly those produced from algin, both sodium and potassium algaenates. These colloids combined with various organic and inorganic acids now make it possible to produce compounds which will dissolve rapidly in water at low concentrations. Their solutions will effectively remove diesel oil film, exhaust stains, and other materials from exterior surfaces, including windows and aluminum bodies.

With the excellent machines now available for steam cleaning, most fleet operators are making this a part of their regular program. But too much emphasis cannot be placed on use of the correct compound for steam cleaning.

Any steam cleaning compound first should be made to treat properly the particular water used in the boiler. It is not possible to use the same chemical treatment in different localities to get satisfactory results. This means there can be no standardized compound for use in a steam cleaning machine which will not form scale in all areas. Scaling in the tubes of these small boilers soon renders them inoperative.

Fifth and last item, cleaning greasy garage floors and driveways, is important from a fire hazard and a safety-to-personnel standpoint. Rice hull ash and other grease sweeping compounds will reduce the formation of grease film from day to day. But

the floor should be scrubbed at least once each week with one of the new type emulsifying compounds to prevent oil and dirt from getting into the pores of concrete, or into wood, and doing permanent damage. (Paper "Industrial Cleaning Problems in the Automotive Industry," was presented at SAE Northwest Section, Seattle, May 6, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Better Lubes Best Solution For Wear

Based on paper by

R. J. FURSTOSS

Caterpillar Tractor Co.

(This paper will be printed in full in SAE Quarterly Transactions.)

IMPROVED lubricants are a simple, economic, and the most easily applied solution to obtain more satisfactory diesel engine performance with those fuels available in specific areas.

Although considerable reduction in both cylinder and ring wear was obtained by changing the engine's design features, not until improved lubricant was used did a major reduction in deposit accumulations occur.

Small bore, medium speed diesel engines are subject to extreme cylinder and ring wear and to combustion chamber deposits when the diesel fuel has a sulfur content above 0.5%.

Wear and deposits produced in this type of engine are jointly influenced by some design and operating characteristics. Separate and distinct effects of high sulfur fuels can be isolated one from the other under favorable circumstances.

Close control of the minimum temperature can minimize cylinder wear resulting from high sulfur fuels.

Corrosion resistant materials will also reduce the amount of cylinder wear, but they must be selected only if economically justifiable.

With either of these methods there is an attendant decrease in top piston ring wear. Hard chrome plating of the top ring proved advantageous in reducing wear.

For many years relatively higher wear rates of engines operating in the field has been attributed to higher amounts of dirt in the engines in the field than in our laboratory engines.

In 1944 two pumping engines in Wyoming, operating on a diesel fuel of somewhat peculiar distillation characteristics and about 2% sulfur, were wearing at a rate of from eight to nine times normal expectancy.

When a basically similar fuel with lighter ends and a sulfur content of 1.1% was used, engine life was extended approximately three times.

These investigations were followed by inspection of approximately 250 engines of a fleet of 150 fishing boats working off San Diego, the Gulf of Mexico, and off Florida.

Use of shielded liners reduced piston ring wear by 25%, and when the engines also were fitted with hard chrome plated top compression rings wear was reduced a half. (Paper "Field Experience With High Sulfur Diesel Fuels" was presented at SAE National Fuels & Lubricants Meeting, Tulsa, Okla, Nov. 4, 1948. This paper is available in full from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Designing Car Seat Trim

Based on paper by

C. H. GRAHAM

Fisher Body Division, GMC

DESIGNING car seat trim for most economical and practical attachment calls for cooperation of the seat frame designer and suppliers.

First step in the process at Fisher Body's trim engineering section is to develop contour templates from the seat frame drawing. Then the springs are designed for size, contour, wire gage, and any special features. Spring manufacturers provide sample springs. While building these samples, they suggest ways to simplify the construction.

Padding is developed according to trim styling and patterns submitted to sources for samples. On submitting these samples, suppliers often suggest better production control methods.

At this point the pattern designers start developing the cover cloth patterns. First step usually is to make up the cushion and back covers out of sheeting material. On these constructions the cover patterns are developed using the production cover material. This ensures proper pattern design, since materials differ greatly in flexibility.

Any changes in spring and padding required to get the right contour are

made in the patterns. If changes are necessary, they are incorporated in the affected part by the source and returned for retrimming for the final cover pattern design.

Patterns for the front seat back and seat ends are laid out to approved styling design and developed on trim sample seats. Individual patterns for the cover assemblies, front seat back, and seat ends are thoroughly checked and then sent to the stencil layout section.

Patterns are layed out on stencil paper, a heavy, durable kraft paper. These stencils are nested as close as possible, taking into consideration the material's nap, stretch, and stripe. In many cases the stencil men recommend piecing the cushions and backs or back of front seat to save material. While this may call for an extra sewing operation, it always yields a substantial overall saving.

It usually takes two to eight job lays to get close nesting of the patterns and the most splices laid in the stencils. This produces a definite saving in material by using up short ends of the rolls.

After nesting the patterns to best advantage, pattern outlines are pencil marked and then perforated with electric burning machines. Duplicates are made from this original perforated stencil and submitted to production plants for marking their trim materials for cutting. (Paper "Production Trim Engineering as Applied to Automotive Seating," was presented at SAE National Passenger Car, Body, and Production Meeting, Detroit, March 8, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Stresses Engine Mated With Torque Converter

Based on paper by

CARL A. LINDBLOM

White Motor Co.

THE torque converter has opened up possible developments for future engine design, since engine and converter now must be matched together and mutually supplement each other.

The low-speed, low-torque, and low-efficiency parts of engine performance curves are made unusable by the converter. For this reason the engine designer now may concentrate on improving the upper ranges of engine performance without having to concern himself with the sometimes conflicting low-speed requirements.

Various means suggest themselves, including mechanically-driven or exhaust-driven superchargers. A mechanical supercharger drive making use of the speed differential across the converter seems possible by using a differential drive. This type of drive would provide engine supercharging in accordance with the vehicle's own torque demand rather than in accordance with engine speed.

With the advent of new prime mover types, such as the gas turbine, the hydraulic torque converter will continue to attract interest as a possible means of supplementing the characteristics of these new powerplants to provide a consolidated unit for automotive vehicle propulsion.

For a brief history of torque converter development and a description of the White Hydrotorque, contained in the paper on which this article is based, see "Hydraulic Drives," by Carl A. Lindblom, pp. 53-57, of the SAE Journal, Vol. 56, October, 1948. (Paper "Hydraulic Drives," was presented at SAE Washington Section, May 10, 1949.)

Design Objectives For Dynamometers

Based on paper by

ROY S. GODBY

Electric Products Co.

DYNAMOMETER design should give top priority to space and time of the service stations where the instrument will be used.

First, the dynamometer must make maximum use of the space it occupies. To do so it should be equipped with all the necessary instrumentation for diagnosis of car troubles.

Second, it must save the operator's time as much as possible. This includes time to put the car on the dynamometer, to connect the various instruments, to run through a test, to diagnose the test readings, to disconnect the instruments, and to get the car back off the dynamometer.

Third, the dynamometer must be simple and quick to install. Its installation must minimize the disruption of normal operations.

And fourth, it must be designed for

minimum service. Its design should permit simple, easy servicing—with a minimum of down time in case of trouble.

Despite the realization of these aims in a dynamometer, it will do the service station operator little good unless he establishes a sound plan for operating the machine. (Paper "The Electric Dynamometer," was presented at SAE Washington Section, Dec. 13, 1948. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Standardized Cockpit Challenges Aeronautics

Based on paper by

COM. HOWARD M. AVERY

U. S. Navy

THE urgently needed standard cockpit, in which any pilot can feel at home with little indoctrination, still remains unrealized, although much progress has been made toward elimination of cockpit confusion.

Already coordination within the military services is showing effect in new production aircraft. The landing gear lever, for example, is in the same place in nearly all new airplanes. Proposed standard knob shapes represent another advance . . . a wheel with tire marks for landing gear level, a simulated flap for the flap lever, and barrel shape for the throttles.

A new ANA bulletin being completed will guide users and designers. It lists an agreed-upon direction of movement for controls. The basic principles are: forward, upward, or clockwise movement for increasing performance of the aircraft or component; the opposite movements for decreasing performance.

It was also agreed that emergency control movements would require additional travel of the normal control, with detents or other devices to prevent inadvertent use. This use of normal controls for emergencies reduces the number of operating controls and simplifies functional movements.

Aero-medical divisions of the services have completed comprehensive reports on human body measurements. Out of this grew standardized placement and travel of the rudder and other controls, so they would be within

reach of even the smallest pilot.

Size and dimensions of console-mounted controls and indicators have been agreed upon; definite functions have been allocated to specific areas—such as the throttle quadrant forward on the left, fuel and trim controls aft of the throttle, electrical controls on the right, followed by communication and navigation control boxes. All are within easy reach of the pilot.

A vital problem now being studied is angles of vision. Ability to see instruments, controls, and markings as well as the runway area when landing without undue eye fatigue must be satisfied by a suitable instrument panel arrangement.

Functional Design

Agencies investigating human engineering urge that the old approach be discarded and a new one started. They feel each item should be carefully considered, so that the required information is presented in such a way that the pilot will be able to take the necessary action.

Getting the most out of our present and future high-performance aircraft demands still greater standardization on a functional basis. (Paper "Cockpit Standardization," was presented at SAE Metropolitan Section, New York, March 10, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Better Back-Up Urged For Radio Landing Aids

Based on paper by

R. C. AYRES

Trans World Airline

OPINION is divided on the relative merits of ILS and GCA for radio-assisted landings. But most agree that need for auxiliary aids, such as better procedures and instrumentation, will make both systems more effective.

Proponents of ILS (Instrument Landing System) and GCA (Ground Control Approach) fall into two general categories. Pilots who fly instrument weather and make instrument approaches on a routine basis generally favor ILS. Preference for GCA is found among pilots who only occasionally fly instruments and make low

instrument approaches. This classification is logical.

The pilot who flies instrument on a routine basis does so with the same ease as he flies contact. With proper training he can fly ILS with little difficulty. Such a pilot is understandably reluctant to turn over part of his most critical job to someone he does not know, and who often may not be a pilot.

But the pilot, for whom a low instrument approach is an unusual experience, is extremely enthusiastic about GCA because it greatly simplifies his job. And unquestionably it is the safer aid for him. Even those pilots who favor ILS generally agree that GCA is easier to fly, but will not agree that it is the safer system for them.

Assuming these comments to be correct, there still must be some justification for selecting one system over the other as the basic one. From the airline viewpoint, obviously the one safest for the greatest number of people is the answer. And if airline pilots are right the ILS system is it.

Despite airline feeling that ILS is the proper choice we are aware that it is not the perfect system and requires a back-up system to insure the highest degree of safety. There is no argument from either the airlines or their pilots that GCA is the most desirable back-up system. But its relatively high cost will make for slow adoption of GCA.

With a basic system and the various back-up possibilities, routine landings will not be made under ceilings much lower than 200 ft. There are several ways of decreasing this limit.

For example, unanimous agreement exists on the need for good runway and approach light systems at all airports where 200 ft and lower approaches are made. Fido is an extremely desirable facility where it can be economically justified. Its high initial and operating costs probably will limit its installation to no more than one-half dozen airports in the next four or five years.

Runway and approach lights emerge as the basic aid to instrument approach below 200 ft. Because under certain conditions these lights will not be completely effective and because instrument-to-contact flight transition may be difficult, some type of back-up aid seems desirable.

One approach is to make the radio aid to instrument approach more useful at lower altitudes. One such promising development is the so-called Zero Reader. Basically this device tells the pilot what to do to keep on the proper approach path, rather than telling him where he is and letting him figure out for himself what to do.

Helps ILS

It gives the airline pilot one of the chief advantages of GCA that has not previously been available with ILS. Because present ILS becomes more difficult to fly (even for experienced pilots) as the touch-down point is approached, easing this job may well permit use of ILS for ceilings considerably under 200 ft.

Another possibility is the use of an automatic pilot for instrument approaches. Greatly simplifying the pilot's job in this way also should make possible lower approaches than are practical today. But the impracticability of providing two auto pilots points to addition of a Zero Reader in those airplanes using automatic approach equipment.

Another solution aims at eliminating the high landing loads induced by present glide slope paths. They make an angle of between 2 and 3 deg with the runway at the point of glide. Developments are under way to provide a flared glide slope. The CAA is working on one system which approaches the

desired condition and lends itself to simple adaptation to existing ILS systems.

It is interesting to note that recommendations recently made by a group of international pilots emphasize improved instrumentation and procedure in the airplane rather than basic elements of the ILS.

Improvements in instrumentation should follow along two lines: first, arrangement of instruments and associated controls that may have to be manipulated during an instrument approach, and second, development of entirely new types of instruments and methods of presentation.

Aircraft manufacturers might make a real contribution in this direction. (Paper "Radio Aids to Instrument Approach and Landing," was presented at SAE Wichita Section, March 17, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

New Members Qualified

These applicants qualified for admission to the Society between July 10, 1949 and Aug. 10, 1949. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (Aff.) Affiliate; (SM) Service Member; (FM) Foreign Member.

Baltimore Section

Jethro Benjamin (M).

British Columbia Group

William J. S. Campbell (A), Dermot A. O'Cadlaigh (A), Claude F. Wainewright (A).

Buffalo Section

L. M. Lawton (M), Clement J. Turansky (M).

Canadian Section

John Alfred McKechan (M), Allan R. M. Millar (A), Thomas George Preston (M), Kenneth Charles Smith (J), Sidney Epey Swallow (A), Roy E. Taylor (A).

Chicago Section

Emmett A. Busse (J), Martin George Gabriel (J), Roger E. Pardon (J), Robert J. Ruppe (M), Eugene M. Sabo (M), James S. Sutherland (A), Raymond S. Vicker (A).

Cleveland Section

Newton D. Baker, III (A), George Fehlner (A), Robert S. James (A), Thomas William Poplett (M).

Colorado Group

Jack Flavin (A), Victor J. Hebert, Jr. (A), Elder T. Rosengren (A).

Dayton Section

Frank W. Brooks (M), Herman J. Martin (J), Leigh R. McCrea (J), William Cedric Potter (J), Richard C. Rike (M), Stuart J. Sietsma (SM).

Detroit Section

Thomas A. Bedford (M), Robert A. Casalou (A), John E. DeWald (M), Omer L. Foret (J), William H. Gay (J), Jack E. Gieck (J), Alfred Haselden (M), F. E. Johnson (M), Cline Verne Larch (M), Sylvester Mazur (J), J. Kelsey McClure (A), William L. Mitchell (M), Clarence E. Morphew (M), Richard L. Pierce (J), Robert W. Ren-

wick (J), Hannes Adolf Ruesch (J), Clyde H. Schamel (M), Carl E. Schreiber (A), Thomas A. Wilkinson (M), Andrew F. Zupanc (A).

Indiana Section
O. W. Fisher (A), Ram T. Tejwaney (J), W. J. Hines (M).

Metropolitan Section
Raymond F. Halen (M), Fred L. Woods, Jr. (J).

Mid-Continent Section
Thomas H. Riggin (A), Walter F. Velgot, Jr. (J).

New England Section
Cornelius J. Harrington, Jr. (J), James Henry Hartwell (J), W. Frank Morrissey (A).

Northern California Section
Robert A. Coit (J), Neal H. Magnus (A), William Edward McComas (M).

Oregon Section
John Ivan Bacon, Jr. (A), Keith B. Cooper (J), Howard I. Martine (A), J. Gerrold Strauss (M).

Philadelphia Section
Frederick Tisdale Cushing (A), Preston Lea Watson (M).

Pittsburgh Section
Raymond Talbot Sendell (A).

St. Louis Section
Donald F. Essen (J), H. Stuart Litzsinger (J), Leonard F. Swoyer (J).

Salt Lake Group
Edward S. Brigman (A).

San Diego Section
Raymond W. Anderson (M).

Southern California Section
John Coates (A), C. E. Deardorff (M), Jack Delbert Linard (A), Robert J. Steiner (A).

Southern New England Section
Harold E. Adams (M).

Spokane Intermountain Section
Paul William Grimm (A).

Texas Section
J. T. Hurry (A).

Twin City Section
Charles B. May (J), Harriet Jean Schmitt (J).

Virginia Section
C. C. Sobeck (A).

Williamsport Group
Stuart W. Steininger (M).

Outside of Section Territory
Paul M. Husby (J), Jack M. Smith (A), Robert James Woolf (J).

Foreign
William John Edmonds (J), England; Edward Reginald Palmer (FM), England; T. S. Srinivasan (A), India; Gordon Heatherton Vokes (A), England.

Applications Received

The applications for membership received between July 10, 1949, and Aug. 10, 1949 are listed below.

Baltimore Section
Stephen Potsko.

British Columbia Section
James William Daly.

Buffalo Section
Richard Miller Weatherly, Martin Philip Wolpin.

Canadian Section
Charles H. W. Cane, John Dietrich, J. G. Inglis, Roy Edward Irwin, George William Richardson, Robert Russell Yuill.

Chicago Section
John W. Curley, A. B. Elliott,

Anthony Granatelli, Wyn E. McCoy, Arthur R. Hempe, Jr., Donald W. Hosford, Richard J. Naras.

Cincinnati Section
Albert L. Hartley.

Cleveland Section
Norman Hilker Brandt, Richard L. DeCosky, Herbert Allen Gustafson, Paul LeRoy Hatleberg, W. P. MacKusick, Harry J. McDevitt, John P. Tierney.

Colorado Group
Ray McBrian.

Detroit Section
Alvin H. Bauman, Jr., William J. Beeler, Richard D. Brewer, John E. Connolly, Robert C. Cornell, Louis Joseph Danis, William C. Larson, Henry Lemark, Robert W. Lemon, Ward P. Mann, Jack Ernest Martens, Gordon H. Millar, Walter Bertrand Mills, Marvin E. Olds, John A. Patterson, Russell M. Richardson, T. Melbourne Roberts, William Edward Sala, Newton Skillman, Jr., Spencer D. Sleight, Daniel Richard Veazey.

Hawaii Section
Thomas S. Putnam.

Indiana Section
Storey M. Larkin, Donald A. Potter.

Metropolitan Section
William C. Hennecke, Donald Vrooman Miller, Irwin Schiff, William Steinle Siebert, Henry James Sugerman, Capt. George A. Tuttle.

Mid-Continent Section
Forrest N. Gaffin.

Milwaukee Section
Ray F. Manke, John Rasmussen, Louis James Svoren.

New England Section
Martin B. Brandt, O. E. Johnson, Milton Arnold Phillips.

Northern California Section
Leonard Peabody Richardson, Charles B. Wall.

Northwest Section
Aaron S. Guthrie, Peter R. Rawn.

Oregon Section
Robert E. Allan, Jack C. Akers, Edward E. Werlein.

Philadelphia Section
Howard Andrew Robertson.

Pittsburgh Section
Don W. Gow, Lloyd George Harrison, Edward P. White.

St. Louis Section
David S. Sandow.

San Diego Section
Frank Osborne.

Southern California Section
Donald R. Bull, Melvin Wiley Hall, Klaus Walter Martens, Richard J. Smith.

Southern New England Section
Paul C. Kennedy.

Spokane-Intermountain Section
William Howard Swalwell.

Syracuse Section
James Greene.

Texas Section
Vincent Paul Citrullo, Harold H. Edwards, Jr., Philip M. Rubins.

Virginia Section
Lawrence J. Gonzer, E. H. Marsteller, Jr.

Washington Section
Herbert N. Johnston, Frederick Billings Lee.

Wichita Section
Benard F. Scott.

Williamsport Group
Philip Barkan, Carl G. Seashore.

Outside of Section Territory
Edmund T. Bielawa, Knud B. Sorensen.

Foreign
Jack Lyndhurst Hepworth, England; K. D. Joshi, India; William Savage, England; Gordon Maskill Smith, New Zealand.

Change of Address

So that your SAE mail will reach you with the least possible delay, please keep SAE Headquarters and the Secretary of your local Section or Group advised of any changes in your address. Such notices should be sent to:

1. Society of Automotive Engineers, Inc., 29 West 39th St., New York 18. N. Y.
2. The Secretary or Assistant Secretary of your Section or Group at the addresses listed below:

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Ward L. Bennett, Baltimore Transfer Co., Monument & Forrest Sts., Baltimore 2, Md.

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Burdette Trout, Suite 6, 1436 Pendrill St., Vancouver, B. C., Can.

Buffalo
Robert W. Morgan, 32 Windover, Hamburg, N. Y.

Canadian
Frank G. King, Canadian Automotive Trade, MacLean-Hunter Publishing Co., Ltd., 481 University Ave., Toronto 2, Ont., Can.

Central Illinois
James C. Porter, 120 Isabel Ave., Peoria, Ill.

Chicago
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Cleveland
(Miss) C. M. Hill, 7016 Euclid Ave., Cleveland 3, Ohio

Dayton
Fred Schwenk, Fred's Auto Hospital, 1522 Xenia Ave., Dayton 10, Ohio

Detroit
(Mrs.) S. J. Duvall, Detroit Office, SAE, 100 Farnsworth Ave., Detroit 2, Mich.

Hawaii
Fred Hedemann, 2110 A Kakela Pl., Honolulu, T.H.

Indiana
Charles K. Taylor, L.G.S. Spring Clutch Corp., Indianapolis 6, Ind.

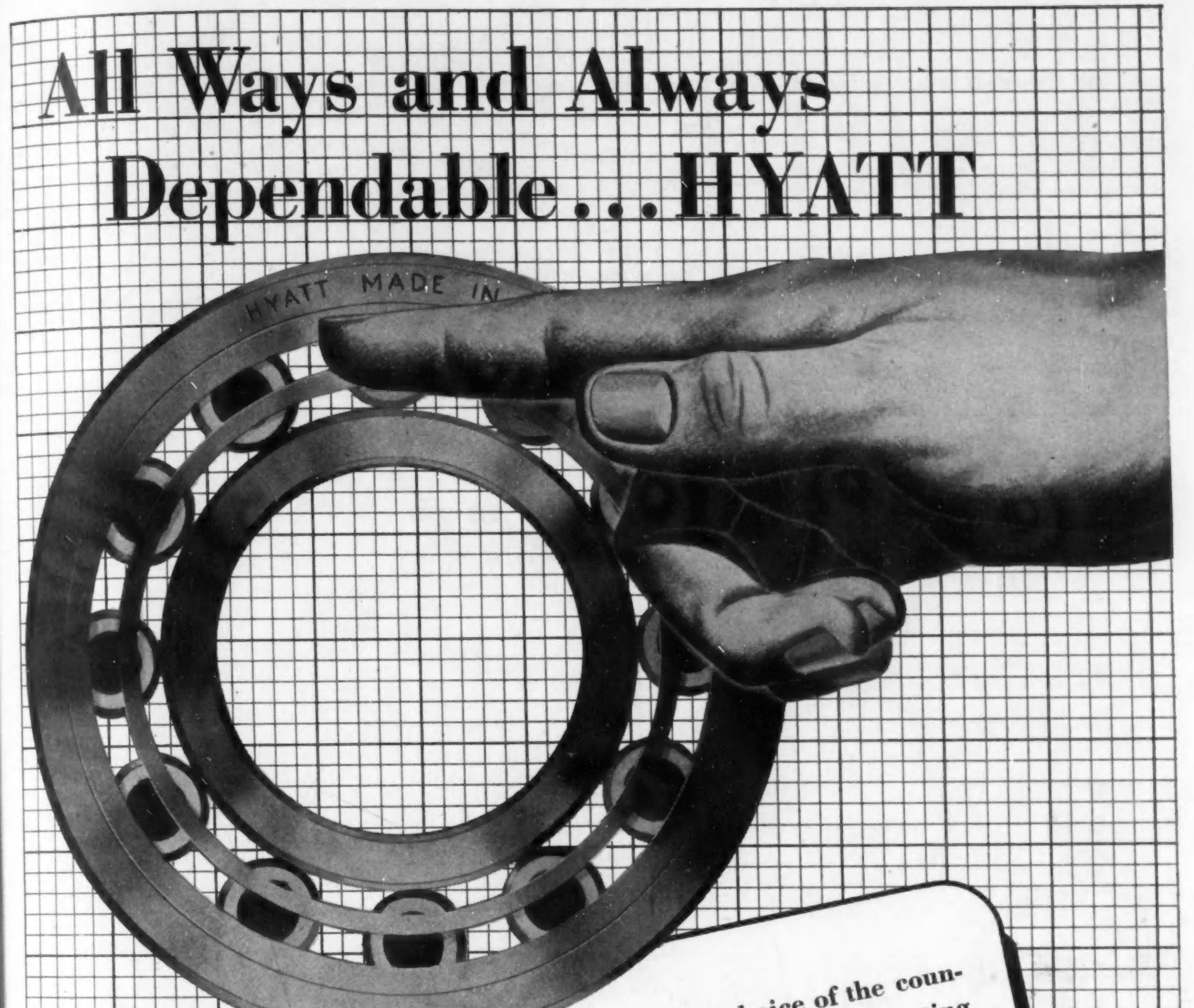
Kansas City
John P. Dranek, Box 304, Grandview, Mo.

Metropolitan
(Miss) J. A. McCormick, Society of Automotive Engineers, 29 West 39th St., New York 18, N. Y.

Mid-Continent
Delton R. Frey, 1427 S. 20th St., Chickasha, Okla.

Milwaukee
Charles H. Duquemin, Le Roi Co., 1706 S. 68th St., Milwaukee 14, Wis.

New England
Edward G. Moody, Ed. G. Moody,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Philadelphia

Linn Edsall, 2301 Market St., Philadelphia 3, Pa.

Pittsburgh

Warren J. Iliff, Equitable Auto Co., 214 N. Lexington Ave., Pittsburgh 8, Pa.

St. Louis

August H. Blattner, Carter Carburetor Corp., 2840 N. Spring Ave., St. Louis 7, Mo.

San Diego

Jerome J. Wheeler, Jr., 7321 Oakwood Dr., Linda Vista, San Diego, Calif.

Southern California

Charles L. Fernau, Standard Oil Co. of Calif., 605 W. Olympic Blvd., Los Angeles 15, Calif.

Southern New England

Alexander M. Watson, 81 Foxcroft Dr., Manchester, Conn.

Spokane-Intermountain

Peter J. Favre, 10 W. Third Ave., Spokane 8, Wash.

Syracuse

Leslie R. Parkinson, 117 Harrington Rd., Syracuse, N. Y.

Texas

Ross A. Peterson, Texas Trade School, 1316 W. Commerce St., Dallas 8, Tex.

Twin City

Wayne E. Schober, 4620 Columbus Ave., Minneapolis, Minn.

Virginia

Robert P. Knighton, Esso Standard Oil Co., Broad & Hamilton Sts., Richmond 21, Va.

Washington

Hyman Feldman, 3222 M St., N.W., Washington, D. C.

Western Michigan

Thomas Reeves, Continental Motors Corp., Muskegon, Mich.

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Virgil W. Hackett, 143 N. Fountain, Wichita 8, Kans.

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